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The Need for Environmental Assessment and Field Surveys in Landfill Location Studies (Case Study: Yazd City)

Sara gilvari[a*],Alireza Mazloumi Bajestani[b],Seyyed Abolfazl Kashfi[c], Alireza Sarsangi Ali Abad[d]

[a] *MSc of Environmental geology, Mahabad Branch, Payame Noor University, Iran*

[b] *Department of Geology, Payame Noor University, Tehran 19395 4697, Iran.*

[c] *Ph.D. student of Environmental geology, Shahroud Branch, Islamic Azad University, Shahroud, Iran.*

[d] *Ph.D. student of GIS and Remote Sensing, University of Tehran, Iran*

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Abstract

The need for a comprehensive management of sustainable environmental development is more than ever due to the growth of population and more waste production. In order to achieve the goals of sustainable development, environmental assessment before, during and after each project is needed. The purpose of the environmental impact assessment is to ensure that managers and experts meet the goals set in a project in accordance with government and environmental regulations. The first step towards achieving this goal will be exploring the study area. In this research, the Leopold matrix was used for environmental assessment of landfill location in Yazd. Environmental assessment was done on the problems resulting from landfill on the environment and living organisms of the area in the environmental assessment area by visiting the field of the current landfill site of Yazd. The total score of the results of the Leopold Environmental Assessment Matrix related to the current landfill site was -214. Therefore, it is possible to carry out management solutions to improve the status of the current landfill. By performing location studies using the hierarchical analysis method, zone one was designated as a suitable landfill site. The soil permeability gradient curve of the selected region was prepared and the soil type of this region was clayey silt. Which will be suitable for landfill.

Keywords: environmental impact assessment, hierarchical analysis, landfill, Yazd city.

[*] Corresponding author. Tel: +98-9130977801.
Email address: sara.gilvary@yahoo.com.

1. Introduction

Environmental impact and environmental pollution caused by solid waste management is a global and inclusive issue in the cycle of pollution of water, air and soil. This mismanagement in developing countries is more harmful to the environment and human society (Ferronato and Torretta, 2019). In order to determine the best choice with the highest profitability and efficiency, the evaluation is used as a method for assessing the environmental impacts of engineering projects. Environmental impact assessment predicts possible potential positive and negative results of the project on the environment before and during the project implementation. This assessment identifies a negative impact management method. Consequently, experts and decision makers will be guided to start or continue the project. The ultimate goal is to decrease environmental pollution so that its adverse effects on plant species, animals and human health are reduced. Environmental impacts of the implementation of the engineering-sanitary landfill project on the parameters of the surrounding physical environment, directly and indirectly, can be separated in two phases including construction phase and exploitation phase. The effects of activity in the construction phase on the physical environment about activities in the short term are irreversible and immediately after the completion of this phase, the exploitation phase will last for about 20 years, which will also have an impact on the environment around the project (Hafezi Moghadas and Hajizadeh, 2007).

These effects whatever they are, there are efforts to reduce or eliminate them in order to achieve the least negative impact on public health, the least negative impacts of the site on the environment, the highest level of service and the lowest cost for users (Yao, 2013).

This issue should be considered that the final selected site is not capable of answering all the problems. Therefore, this site should be less damaging to its environment than other sites. In other words a special tool should be used to identify the negative effects of the project. There are many ways to determine the priority which has the characteristics and properties that experts have considered. Therefore, there are several methods for assessing the environmental impacts that require a variety of technical and information layers to use and analyze them. The best and most practical methods should organize a large amount of data, summarize the data in a smaller format and display raw data related to each other. The spatial information system provides the spatial information necessary for users to evaluate the site. In other words, the system will be a useful tool in environmental assessment of management and decision making (Zamorano et al., 2008).

Kapilan and Elangovan (2018) did a research titled "Selection of the potential landfill for solid waste disposal using GIS and multi-criteria decision analysis" in Coimbatore in India. The model used for weighing in location using geographic information system was a hierarchical analysis method. The data layers used in multi-criteria decision analysis included population density, underground water depth, drainage density, slope, soil texture, geology and geomorphology. By applying the final weight of each layer by this method, seventeen locations in this area were identified. By reviewing through the field survey of the area, eventually, four areas were identified as suitable for landfills.

Jafari et al. (2015) did a research titled "The final choice of landfill site in Ardebil based on methods similar to the ideal option and environmental impact assessment". The model used for weighing in location using geographic information system was a hierarchical analysis method. After creating a final map of waste landfill by conducting field visits from designated and collecting necessary information from these places, four suitable landfills were placed in the appropriate category. Then, to determine the most suitable location using a method similar to the ideal option and the Leopold matrix method these four places were evaluated. The results of the assessment by using two methods indicated that the prioritization of the options with a method similar to the ideal option is equivalent to prioritizing options by assessing the environmental impacts of the Leopold Matrix and the first option is the first priority. They finally said since the groundwater level in this place is low, the depth of soil is high and access to borrow pits is easier, urban waste disposal in a trench method would be more appropriate at this location.

Gilvari et al. (2015) conduct an investigation titled "Environmental assessment (EIA) and optimum locating of solid municipal waste landfill using GIS, SAW method and the Leopold matrix (case study: Yazd city) ". Required information layers including geology, land use, distance from city boundary, slope, distance from road, vegetation, permeability and hydrology were provided to weighting using simple additive weighting. To determine the proper burial location three stages were carried: location of susceptible areas of landfill, field visit to study the characteristics of susceptible areas and environmental assessment using the Leopold matrix to rank the areas and select the optimal location. Initially, the final map of the

appropriate places for landfill was classified, and four locations were in the appropriate category for landfill dumping. Then, field visits were conducted from selected areas in order to confirm the locations according to limitations of their ability to landfill. Finally, using Leopold Matrix method, region 1 was identified as the optimum location for sanitary-engineering waste landfill. Moreover, using this matrix, it was found that the greatest environmental impacts of landfill construction in the study area are physical effects which the construction and operation of landfill can create in the area and adjacent lands. Therefore, it takes a lot of care to run and operation landfill to minimize these effects.

2. Materials and Methods

2.1. The Study Area

Yazd city, the center of Yazd County, with a total area of 107 square kilometers, is located in the center of Yazd province. The city is located on the coordinates of 54 ° and 9′ to 54 °, 31 ′ east longitude and 34 °, 31 ′ to 32 °, 10' north latitude. In this study, the radius of 30 km from the legal boundary of Yazd city was considered (Figure 1).

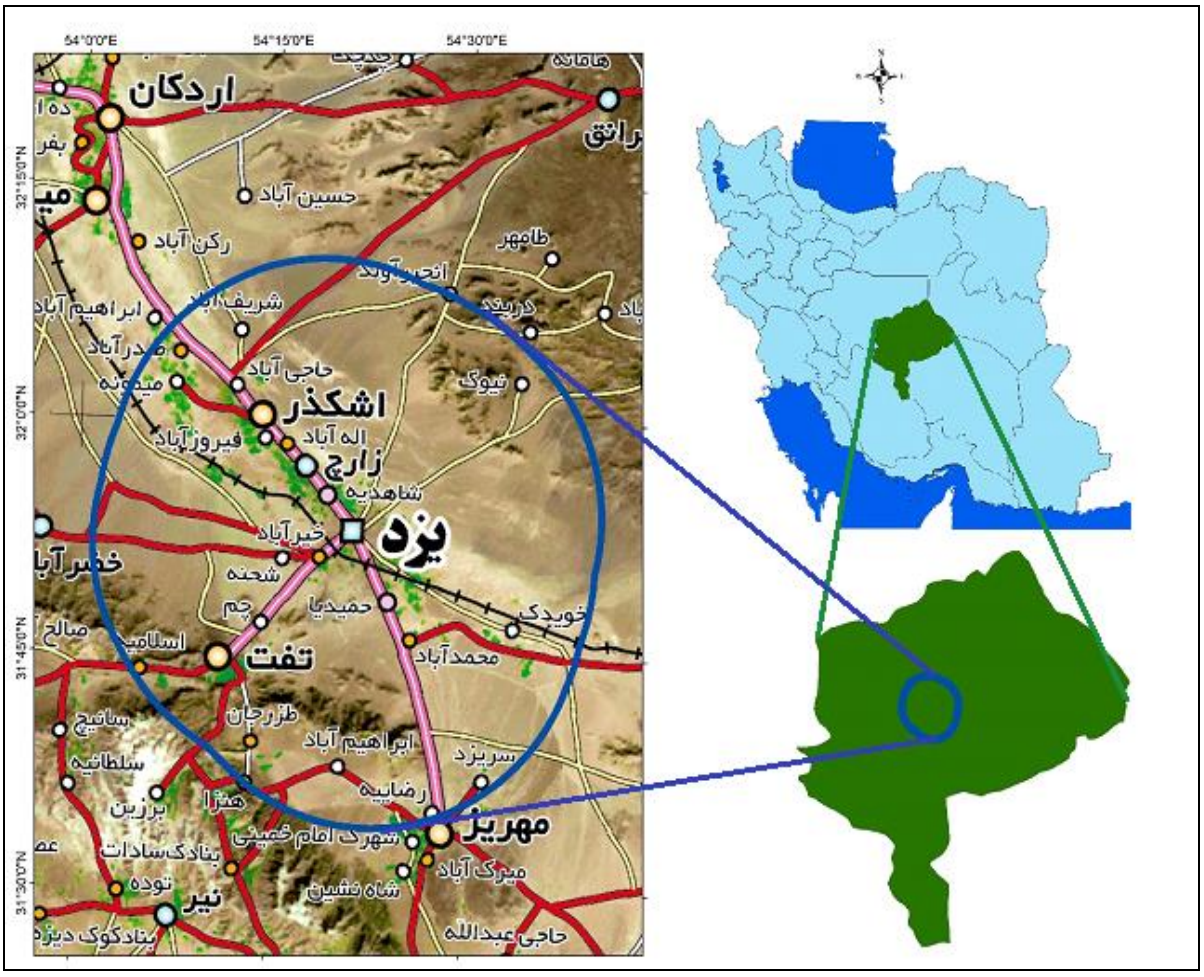

Figure 1. Location of the study area in the country and provincial divisions

2.2. Methodology

Initially, the environmental assessment of the current landfill site of Yazd city was done using the Leopold matrix method and then using the hierarchical analysis method in the arcgis10.9 software environment. The final selected area was evaluated by field surveys and soil permeability tests. The first step in assessing environmental impacts is studying the status of the study area, including environmental elements influenced by the project as well as the target chain which different levels of pollution have different effects on it (Zamorano et al., 2008; Butt et al., 2008).

For this reason, the physical, biological, economic and social parameters and in the next step, the effects of the project on each of these parameters will be investigated. One of the things which can make the landfill undesirable is the stench of waste in the landfill site; climate changes will affect the intensity of odor (Naddeo et al., 2018).

Table 1 shows the environmental impacts on the landfill site during the construction and operation phase on the physical environment (Farhadi and Hafezi Moghadas, 2006).

Table 1. The environmental impacts on the landfill site during the construction and operation phase on the physical environment (Farhadi and Hafezi Moghadas, 2006).

Effects	Construction stage	Operation stage
Effects on the biological environment	• The probability of invading some non-native species of plants due to destruction of vegetation cover of native species and the cultivation of non-native species • Destruction of the natural habitat of animals living there • Possibility of few changes in wild life	• Effects on plants due to gasses from the landfill site • The probability of increasing non-native plant species • Destruction of wildlife habitats due to land occupation • Reduction of animal population due to the movement of machinery
Air pollution	• Partial increase of air pollutant gases • Increasing suspended particles due to the movement of machinery	• Gas production from waste • Production of organic compounds from waste
Pollution of water resources	• Changing the channel of the area causing changes in the hydrologic regime • Making bad changes in the water due to the construction of the production workshops which are resulted during rainy season and runoff	• pouring and spread of pollutants, industrial and oil waste along roads • Oil and fuel leakage and distribution on the surface of the soil and entry into groundwater resources
Pollution of soil resources	• Destruction of soil at the site of construction workshop • Destruction of soil for leveling the path of the road • Excavation in the area to supply borrow soil • Leakage of leachate into soil	• Distribution of solid waste on the soil • Leakage of leachate into soil • Soil subsidence due to lack of waste consolidation
Noise pollution	• Noise pollution caused by Vehicles traffic • Noise pollution due to drilling tools and equipment	• Noise pollution due to the operation of load-carrying devices such as forklift and trucks

One of the methods of environmental assessment is the use of the two-dimensional and matrix comparison method. Matrices are, in fact, two-dimensional checklists which the project activity is based on an axis (horizontal axis) that effective activities are in the process of disposal and landfill. On the other axis (vertical axis) is the effects of project activity on the physical, social and biological environment around the selected area (Canter, 1996). This method is used to identify cause-and-effect relationships, between specific activities

and effects, and it provides a special contribution to further studies. The most common type of matrices is the Leopold matrix (Farhadi and Hafezi Moghadas, 2006). Each unit of the matrix represents two values of the relationship between the activities and the project as a positive or negative number. Below the fraction of each unit of the cell is the magnitude of the effect and its value varies from 1 to 5 (low to high). At the top of the fraction of each unit of the cell is the value of the cell and its value varies from -5 to +5 (harmful to useful) (Leopold, 1971). The matrices only represent the direct effects and emphasize biophysical issues. In other words, the timing or duration of the impact period is not mentioned. In this method, the best location with the highest degree of importance and positive intensity of the layers is determined (Shariat, 2000). The expert, by visiting a field of the desired areas, determines the severity and significance of the effects in the scoring of each of the factors in the candidate regions. Zoning and locating susceptible areas for waste dumping using hierarchical analysis technique were done which were established based on the three principles of analysis of the problem, the creation of a paired comparison matrix together with determining the relative weight of the priority of the variables and achieving the real value of the weights after determining the adjustment rate. Firstly, for each of the information layers, the comparison matrix is formed. A higher score indicates the value and importance of the layer in the locating process (Gilvari et al., 2016). A higher score indicates the value and importance of the layer in the locating process and the value of each layer is determined by the other (Guiqin et al., 2009).

3. Results and discussion

The current landfill site of Yazd city is located at km 4 Azadegan Cement Road, 4 km from the legal border and 11 km from the city center of Yazd city. This place has been used for this purpose for at least 45 years ago. This location is located in the geographical coordinates at 31º55 ′ 55 ″ on the north latitude and 54º25′59″ on the east longitude, in the northeast of Yazd. Figure 2 shows the current location of the landfill site of solid waste in Yazd.

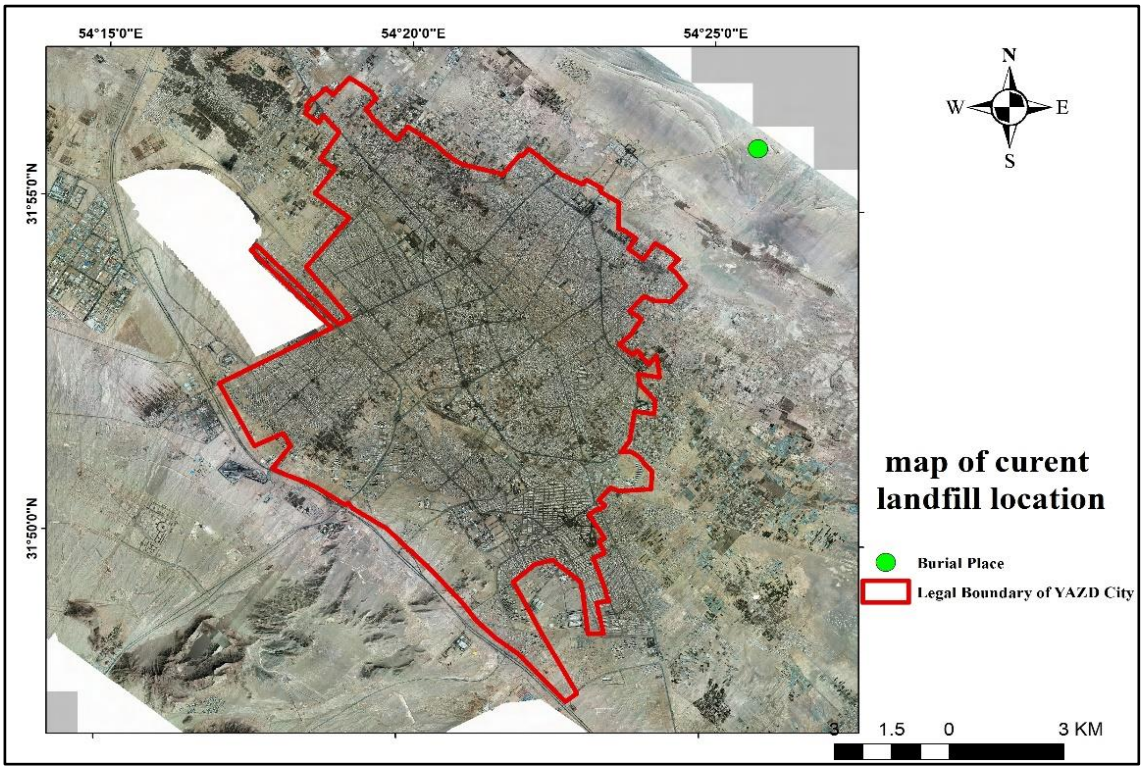

Figure 2. Current location of the landfill site of solid waste in Yazd

The problems encountered in field visits and surveys include:

- Unusual and non-engineering waste landfill (The burial is carried out continuously for years without daily coverage without compression of the layers, which is likely to cause leachate leakage, gas leakage and slippage in the landfill location),
- No specific scheduled landfill (landfill in different places in the last 45 years),
- Infectious waste landfill and construction and demolition waste beside urban waste near the border and without proper burial coverage,
- Urban sewage drainage near the municipal landfill and becoming sewage lake,
- Absence of landfill fence,
- The presence of unlicensed separators that search inside infectious and urban waste,
- Presence of birds (rare species such as Eagle and Hawk) and wild animals that feed on garbage,
- The landfill around the road is sometimes done and the privacy of the main road is not met,
- High distances from the current landfill site (about 8 km) from the composting plant,
- Bad smell, mosquitoes and flies that it annoys passengers who cross the road because of proximity to the main road,
- Non-separation of waste for the purpose of consuming garbage fuel and a composting plant,
- Absence of observation wells around the landfill site to investigate the risk of contamination caused by leachates,
- Extreme rainfall, though short-lived, causes leachate and animals feed on garbage in relation to it.

Table 2 shows the Leopold matrix for assessing the environmental status of the current solid landfill site in Yazd.

Table 2. The Leopold matrix for assessing the environmental status of the current solid landfill site in Yazd (Gilvari et al., 2014).

Total	Leakage of leachate	Methane gas leakage	Traffic machines	Extraction of loan resource	Daily burial	Construction of landfill	infrastructure	flatten	Excavated	Construct Access road	Operation / Environmental impact		
-140	-32				-44						Soil pollution	soil	Physical
								-43	-43		Soil erosion		
	-33				-33						Surface water quality	water	
	-44				-34						Groundwater quality		
				-43				-43	-43		Dusty production	air	
		-43									Creating an unpleasant odor		
-60						-21		-11	-11	-21	plant species	environment	Biological
			-32								Animal species		
	-43	-42			-32						Public health	Human	
		-32			-44						Sickness (by animal)		
-14						13	11			12	Create a job	economic	social – economic
										-11	Agriculture		
						-11	11				Animal husbandry		
						-41	11			11	Land values		
						-21	11			11	Future development	social	
			-21								Creating traffic		
						-33					Beauty Landscape		
						-22					Area tourism		
			-21								Increased accidents		
-214	Total results of Leopold's environmental assessment matrix related to the current burial site												

In this study, ten layers of information including geology, topography, soil permeability, land use, distance from the city, vegetation, the distance from the main road, the distance from the power lines, the

quality and depth of the groundwater have been used. Depending on the extent of the impact on locating these layers are classified by the expert choice software in the software environment of arcgis10.9 into four classes including: highly suitable (class 1), suitable (class 2), relatively suitable (class 3) and inappropriate (class 4). Figures 3 to 12 represent the map of classification of these layers in Yazd city.

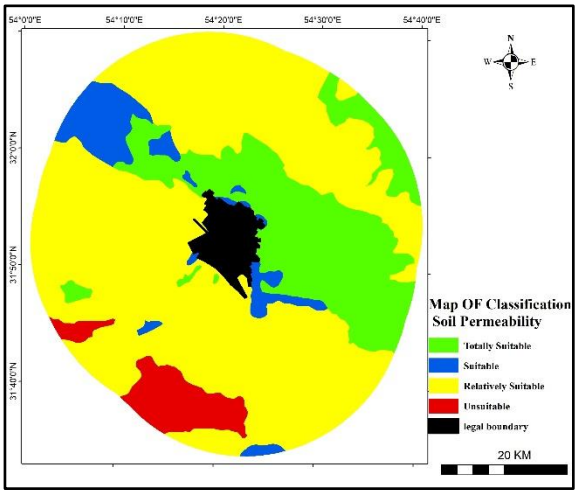

Figure 3. Map of classification layer soil Permeability of the study area (Gilvari et al. a.2019).

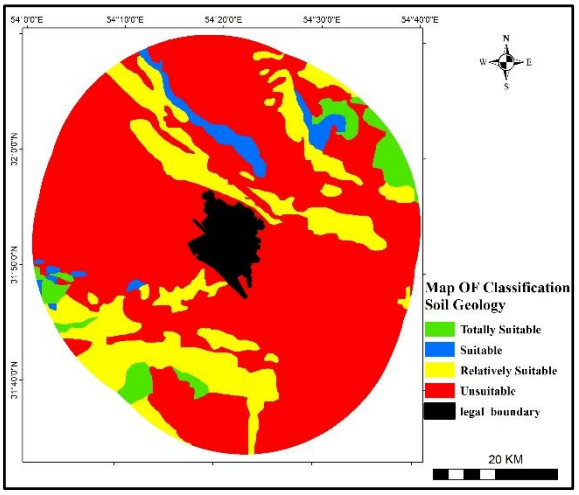

Figure 4. Map of classification layer Geology of the study area (Gilvari et al. a.2019).

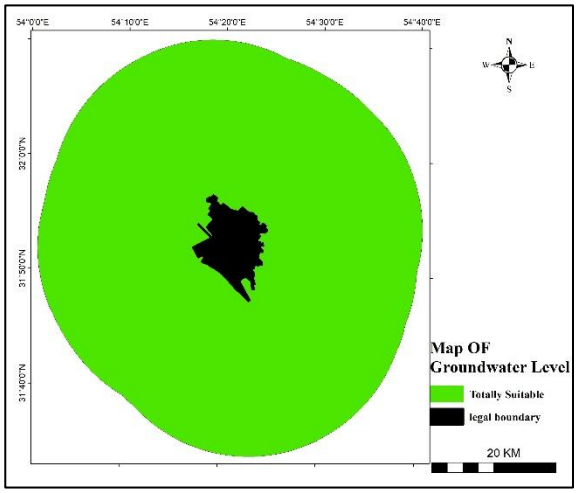

Figure 5. Map of classification layer Underground water depth of the study area (Gilvari et al. a.2019).

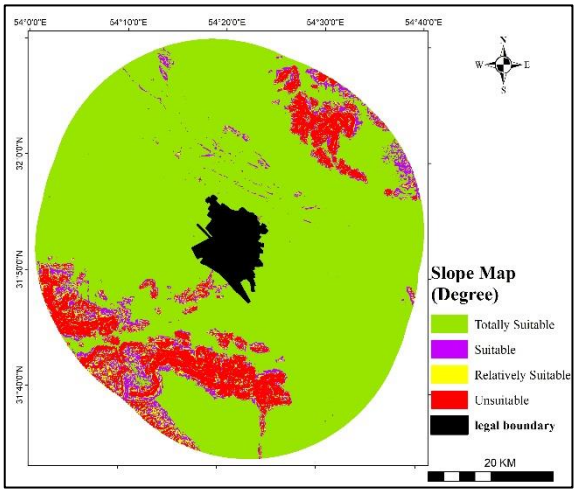

Figure 6. Map of classification layer slope of the study area (Gilvari et al. a.2019).

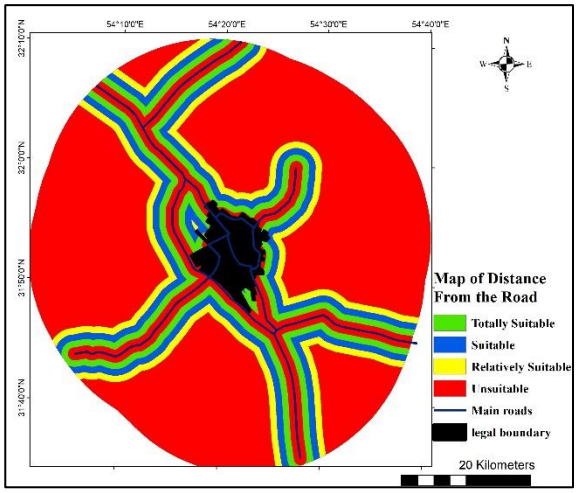

Figure 7. Map of classification layer Distance from the road (km) of the study area (Gilvari et al. a.2019).

Figure 8. Map of classification layer Distance from the city (km) of the study area (Gilvari et al. a.2019).

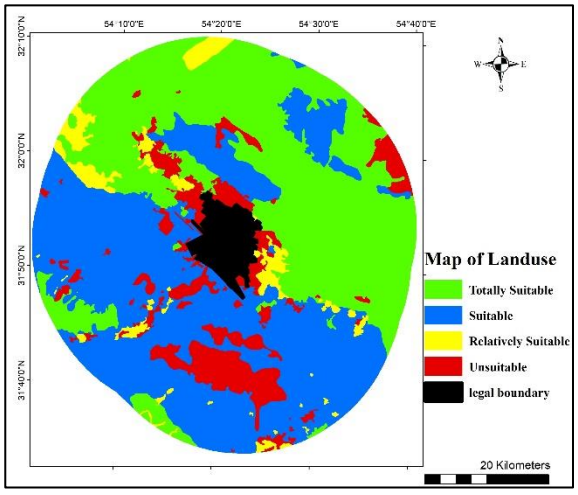

Figure 9. Map of classification layer Land use of the study area (Gilvari et al. a.2019).

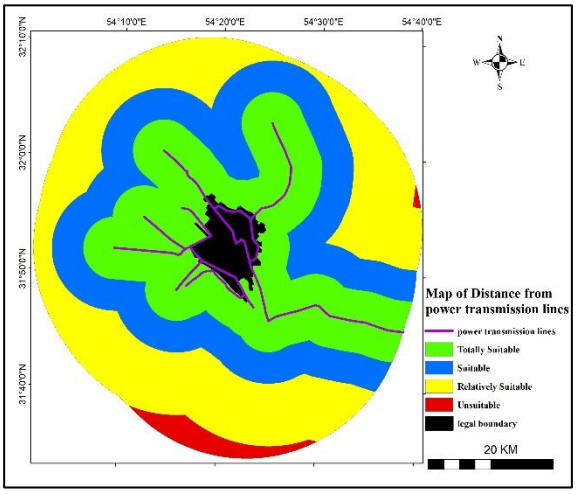

Figure 10. Map of classification layer Distance from power transmission lines (km) of the study area (Gilvari et al. a.2019).

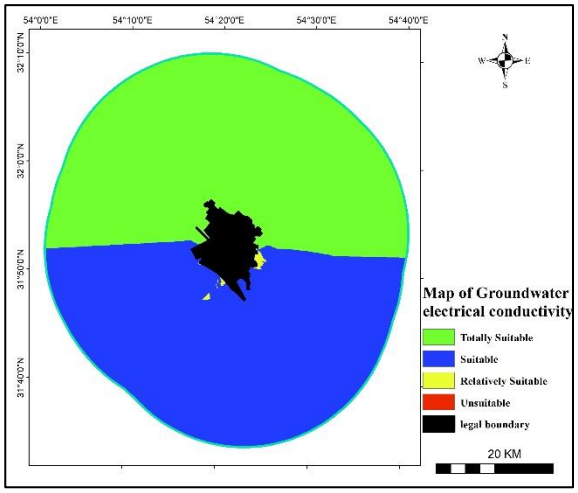

Figure 11. Map of classification layer Groundwater electrical conductivity of the study area (Gilvari et al. a. 2019).

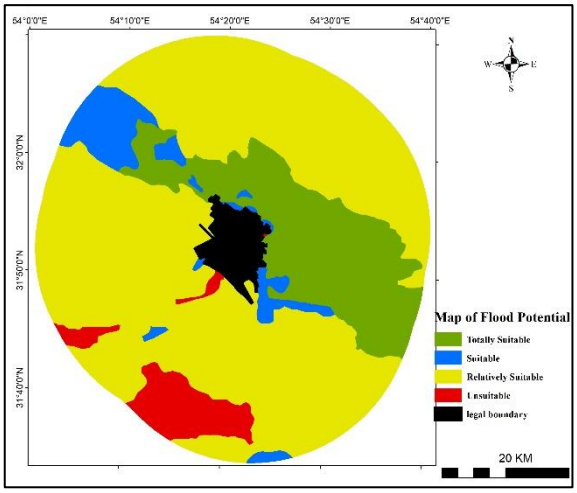

Figure 12. Map of classification layer Flood potential of the study area (Gilvari et al. a.2019)

Figure 13 shows the final map of suitable areas for landfill with weighting through the hierarchical analysis method.

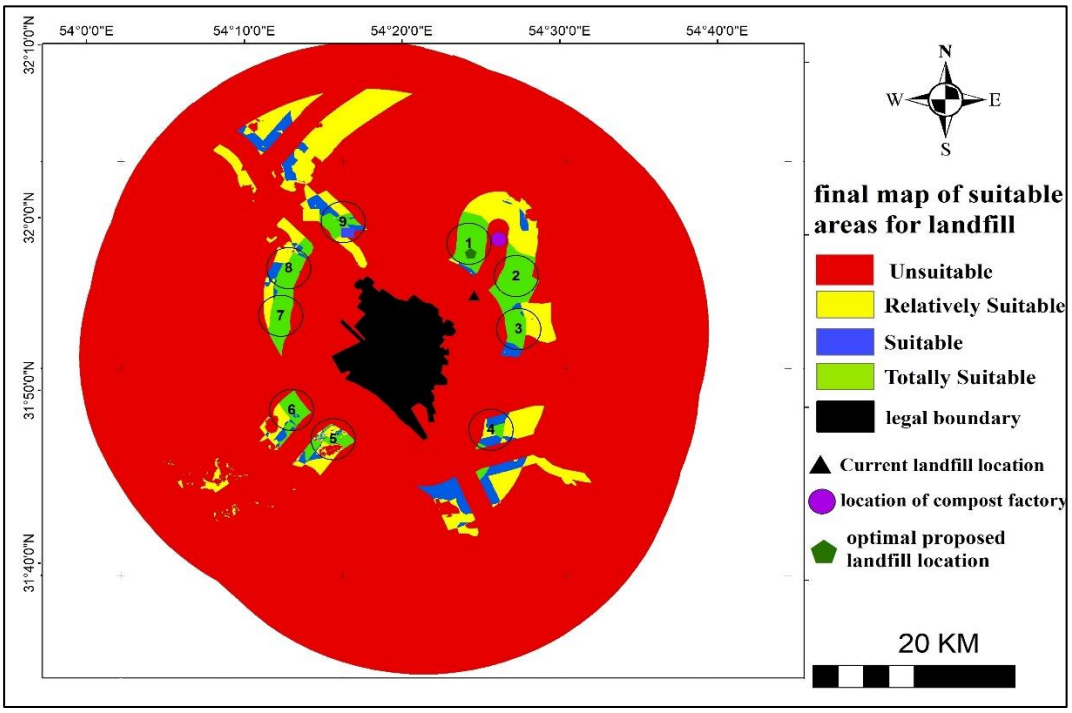

Figure 13. The final map of suitable areas for landfill with weighting through the hierarchical analysis method at a radius of 30 km from the border of Yazd city (Gilvari et al. b. 2019).

Here, it is necessary to ignore some of the selected locations, due to limiting factors such as dominant wind direction, minimum area required for landfill, in a multi-year perspective (at least 20 years), given the volume of waste generated and etc. Since the dominant wind direction is Yazd, the west is northwest and

southeast As well as taking into account the minimum area required in the 20-year horizon for landfill, with areas larger than 278 square kilometers, all areas except 1, 2 and 3 will be unsuitable. By conducting a field survey of these three areas, considering the environmental assessment of experts and considering such things as view perspective, access to compost plant, road access geological conditions and etc, Area 1 is appropriately detected.

Then the final selected area was examined by field visit. The field survey results are presented in table 3.

Table 3. Field servey of the proposed solid landfill site in Yazd city

Parameter checked in selected region	Results
Groundwater and surface water	The groundwater level in the study area is over 50 meters, there were no main and secondary streams in the area, in terms of flooding, the area is in a relatively suitable area
Plant and animal species	The area is idle with scattered vegetation, there was no specific animal species in the region
Agricultural and animal husbandry activities	In the region, agriculture and animal husbandry activities are not carried out
Distance from the main road	Distance from the main road is appropriate, road traffic is low
The value of the land	The area is idle and is not in the urban development plan
Tourism and protected areas	The area is not in the tourism and protected plan
Distance from prohibited zone	The selected area is not limited by any limiting factors
Infrastructure and power lines	Because of its proximity to the composting plant, power lines and infrastructure are available

In Figure 14, an overview of the final selected zone (area 1) is presented using a hierarchical analysis method.

Figure 14. Overview of the final selected zone (area 1) for a new landfill site in Yazd

To ensure the soil conditions of the final selected area, permeability and granulometric composition of soil were investigated. For this purpose, about 3 kg of soil area was investigated in Yazd soil mechanics laboratory. According to figure 15, sieve analysis curve is 6.2 × 6 cm / s. The soil type is clayey silt. This type of soil is suitable for landfill (Niknami et al, 2009). Due to the high depth of water in the area, trench method with a high depth can be used in the area as well.

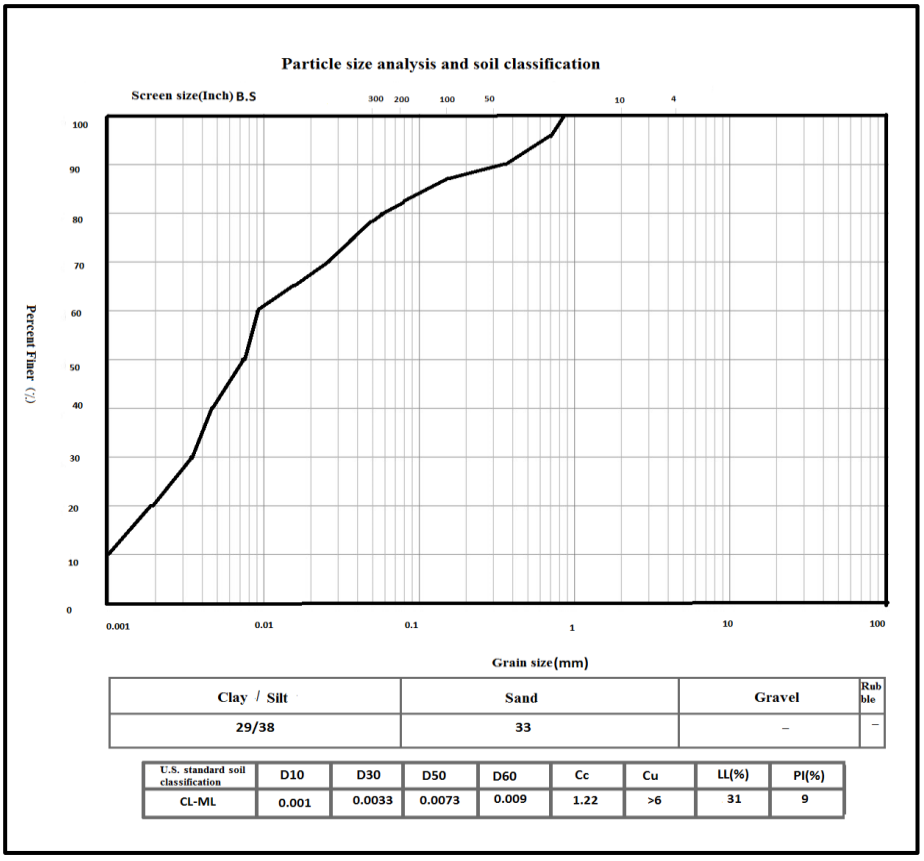

Figure 15. The soil permeability gradient curve of the selected region

4. Conclusion

In this study, the need for environmental assessment in landfill location studies of solid landfill in Yazd using the Leopold matrix method has been emphasized. By field visit from the current landfill site, bad effects of landfill on the environment and living organisms were studied ecologically. The total results of the Leopold Environmental Assessment Matrix related to the current landfill were -214. Since the most environmental impacts of landfill construction in the study area related to the physical effects that the construction and operation of landfill can create them in the area and the surrounding lands and areas, it is necessary to be very careful in the implementation and operation of landfill to minimize these effects. Therefore, management solutions can be developed to improve the status of the current landfill. Since the dominant wind direction is Yazd, the west is northwest and southeast As well as taking into account the minimum area required in the 20 year horizon for landfill, with areas larger than 278 square kilometers, all areas except 1, 2 and 3 will be unsuitable. Locating the burial place was determined by analyzing the hierarchy. By conducting a field survey of these three areas and considering the environmental assessment of experts, area 1 appropriately detected. The sieve analysis curve of the selected area was created and the soil type of this region was determined as clayey silt. Table 4 presents technical proposals for the construction of engineering-sanitary of landfill site in Yazd city.

Table 4. Technical proposals for a better landfill operation in Yazd city

Actions	Description
surface drainage	Surface drainage is required to reduce the risk of rain or flood entry, of course, it is not a flooding area and the main stream was not seen and the gentle slope of the area also helps to collect water.
Excavation and embankment	Since the area is flat and the slope is gentle, no need to transfer too much soil and it saves time and cost.
Substrate preparation	Since the soil in the area is clayey silt, the substrate is isolated by soil compression and no need for costly isolating materials.
Wall preparation	The wall is suitable with slopes of 135 degrees or less, since the depth of the underground water is high, it is possible to construct deep trench about 8 meters.
Leachate collection system	At the beginning, digging and filling the pit should be taken from the lowest point of collecting leachate in order to from the beginning of the work, the leachate is collected by the tube, then it is transferred to the tank next to the burial site to evaporate.
Gas collection	Tubes and wells are required to collect gas to reduce the smell, reduce the risk of fire and generate electricity
Wind and water erosion control	The excavation should be stopped during stormy and rainy days (heavy rainfall), moreover the erosion is reduced by planting around the landfill site
Underground water monitoring sump	A deep sump should be built to control underground water in terms of waste and leachate regularly
Reuse	After the landfill closes, after 10 years, buildings can be built on it with compression and also it can be used to create green space and playground
Geotechnical study	To study the land conditions for creating, stabilizing and keeping the landfill, geotechnical and geophysical studies will be needed
Vegetation	Vegetation of the area is low density, it is possible to plant trees and plants in the crown of the landfill to reduce erosion and create a beautiful view.
Fencing	Lightweight fencing is recommended to prevent unauthorized and also domestic and wild animals entry
Creating Infrastructure	Since its proximity to plant composting, it is possible to create infrastructure with low cost
Design of landfill cells	The complete map of the landfill, along with the location of the cells, the location of collecting leachate and gas is required, it is also possible to isolate the material inside the cells by creating a bump inside the cells not to be in contact
Waste separation	Waste separation is done before landfill for use at the composting plant
Control of insects	Regular and periodic spraying of the landfill site to prevent the spread of vermin, especially phlebotomus mosquito that it exists in Yazd
Preparation of evaluation report	It is need to prepare environmental reports before and during operation and after closing to control effects of landfill on the environment
Daily coverage	During day, waste compression should be done by heavy weight or bulldozer and at the end of the day with a meter of soil, the surface of the garbage should be covered.

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