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Application of local scale screening method for evaluation of urban solid waste landfill

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ABSTRACT

In solid waste management planning, attention to environmental criteria has high important role. In this paper, with using of GIS, evaluation of Rasht solid waste landfill by local screening approach was studied. In this method the main criteria are physical, economical, conditions, and land use. These criteria contains 14 factors which can be used into the over layer technique to determine some appropriate conditions in a vast region. Results showed that Rasht solid waste landfill has very weak value in local scale.

Keywords: Screening Method, Local Scale, Evaluation of Solid Waste Landfill, Rasht County

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INTRODUCTION

Urban development, population growth and the changes in life style including consumption patterns, have created numerous problems that dealing with them is inevitable [1]. One of these problems is waste management, particularly solid waste landfill [2] .Generally; solid waste landfills have inconsistent consequences in the condition of the lack of health- environmental considerations on their surroundings [3]. That's why always activities in this situation face community opposition [4and26].

Management problems of landfilling solid waste in humid areas, is considered as a more complicated process due to its special environmental and geographical characteristics [5]. In these geographical areas of special formations, climate, ecological, population and economic characteristics are different from central plateau of Iran. So, there are more problems to deal with problems of solid waste landfill. Landfills with environmental and health problems require scientific knowledge and attitudes to provide appropriate and reasonable options according to the most fundamental scientific and timely available capacities [6and25].

According to this fact that selection of urban solid waste landfill in Iran is mainly performed without primary investigations, [7and24]. Therefore it is important to identify and evaluate solid waste landfill to prevent possible contamination [8 and 9]. In this study, appropriate level of solid waste landfill is determined in Rasht city using screening method in a local scale and preparing different layers in the GIS environment. It could be used as first step in any kind of planning to meet existing problems in the area of study.

MATERIALS AND METHODS

A. Study area

Rasht city as capital of Gilan province is located in the eastern latitude of 377845 and the northern latitude of 4103410 UTM [10] (Fig. 1). Population in this city in a 20-years period from 1991 to 2011 was increased from 611 946 to 857 606 and with possible growth of 7/1 percent it will be increased to 1.12074 million by 2020 [11]. The average annual precipitation at Rasht city stations during 1976-2010 was 4/1351 mm and average annual temperature was 17/4° C [12]

Rasht The input solid waste to this site is 620 tons per day which are transferred from 14 cities, 12 villages, 11 organizations and governmental companies, 9 livestock companies, industrial estate, hospitals, health and treatment centers and buried with valley disposal method [13]. The non-sanitary landfill method is performed in Saravan valley [14]. This area is located in alluvial – river plain river. Siahroud River at a distance of 3 km of this place flows into Anzali International wetland after passing through Rasht city and connecting to Goharrood River in the name of Pir-Bazar River [15]. Discharge of this river adjacent to the site area in Behdan village is 3.71 m^3/s

Groundwater at the landfill is carbonated formation, and originates from the Neizehsar mountains. The Safidrood River is in the distance of 8 km along site. The location of the seismicity of moderate to heavy damage in the region is located at an altitude of 180 meters above sea level [16]. The main plant community of forest lands in this area is Alder. Indeed it is the habitat of Pheasant (*Phasianus colchicus*) [17].

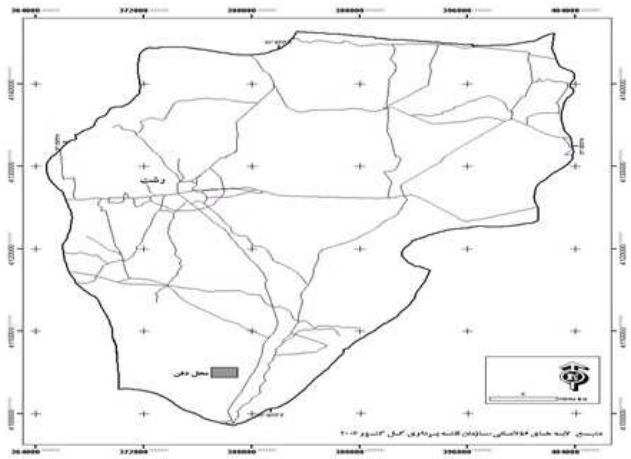

Fig. 1 Rasht County and Solid Waste landfill

B. Methods

Required materials and data for this study are as follows:

1) Topographic maps with the scale of 1:25000
2) Geological map with the scale of 1:100000
3) Underground water map and distance maps from the wells
4) SPOT satellite data (2008)

In addition to the map, slope classification map, slope direction map ,slope elevation map, fault map , map of distance from main roads, map of transmission lines and surface waters are prepared using the existing topographic maps. Land use map was also prepared using SPOT satellite image in 2008.

Software used in this study includes:

- Autodesk map 2004 software for digitization and editing operations of the map
- Envi 4.3 software for image processing operations and land use mapping.
- Idrisi 15 software for normalization operations of the map
- Investigation of factors

The Analysis Procedures:
Factors in local screening are classified in to 3 main conditions including:

- *Natural conditions;*
1) Depth of appropriate soil for the landfill cover layers: Areas with sandy, silt and clay soils are suitable to cover solid waste landfills and soils without these properties should be eliminated.
2) Available deep lands: deep lands created by people or by drilling are suitable for landfill, but natural deep lands are not suitable.
3) Natural cover of landfill in public view: areas with natural cover for landfill (such as trees and natural embankment) are also appropriate.
4) Density of water wells: areas with lowest water wells are appropriate.
5) Easy sampling of groundwater: areas with complicated underground water regime, with difficult data preparation and interpretation of water quality control are not appropriate.
6) Slope of the ground: areas with slopes greater than 40% are not appropriate.
7) Landscape: areas that require more spending to create landscapes in the landfill are not suitable.
8) Depth of groundwater level: areas with low groundwater level and high depth of the half-saturation are suitable. Areas with high underground water levels are inappropriate, unless to be designed by a hydraulic trap.

- *Land use*
1) Privacy of landfill: areas in which additional spending is required for landfill are inappropriate.
2) Land use after closing landfill: it is recommended not to use landfill final cover layer for its healthy status and left as open space. Sometimes it is recommended to create park or green space.
3) Urban areas privacy: areas within urban environment with regulatory barriers are not suitable landfill.
4) Areas with environmental protection: landfill should not be located in areas with environmental protection importance.
5) Areas with limited road traffic rules: roads in landfill areas should be controlled in terms of machineries that carry wastes. Traffic limitations also should be investigated. Road areas with traffic limitations are not suitable.
6) Landfill impact on traffic: landfill impact on traffic should be investigated.

- Economical factors
1) Distance from the center of solid waste generation sources: a waste transportation cost is about 50 percent of waste management costs including construction costs. So, areas where the cost of solid waste transporting is high are not suitable.
2) Ability to purchase land: some selected areas of local scale may be subject to sales and they will be eliminated automatically.

Among the conditions listed as criteria of landfill area and its status, three following options should be omitted:
- Regions with high gradients (more than 40 percent).
- Areas of historical and religious importance.
- Important environmental areas (sensitive habitats).

At this stage of study, weight and score methods will be used. Table I, indicates weight of each of the parameters. In this stage, higher scores indicate better place for landfill. Scores of each parameter is presented in tables II to XV.

TABLE I: Studied parameters in local scale and their weight

Parameter	Weight
A – Natural conditions	
Depth of appropriate soil for the landfill cover layers	4
Available deep lands	1
Natural waste burial landfill in public view	2
Density of water wells	5
Easy sampling of groundwater	5
Landscape of landfill	2
Depth of groundwater level	5
B - Land use	
Landfill privacy	2
Using landfill after its closing	1
Privacy of urban areas	1
Areas with limited road traffic	3
Landfill impact on traffic	4
D - Economical factors	
Distance from the waste production center	4
Ability to purchase land	3

TABLE II: Scores range of the parameter of appropriate soil depth for landfill cover layers

Limitation of soils depth	Scores
Soils with a depth of 6 to 10 meters	6-10
Soils with a depth of 10 to 15 meters and more	3-6
Soil level is low and extra soils should be provided from other areas.	1-3
Soil is not available, geosynthetic materials should be used.	0-1

TABLE III: The scores range of available deep lands

Volume percent that deep land creates for the landfill and proportional the total required volume	Scores range from
Available deep land creates more than 25 percent of the required volume.	5-10
Available deep land creates more than 10 percent of the required volume.	3-5
Available deep land creates more than 5 percent of the required volume	1-3
Deep land contained more than 2 percent of the required volume	0-1

TABLE IV: Scores ranges of natural coverage parameter of the landfill in terms of public view

Natural cover landfill percent	Scores ranges
Natural coverage can cover more than 25 percent of the landfill	5-10
Natural coverage can cover more than 10 percent of the landfill	3-5
Natural coverage can cover more than 5percent of the landfill	1-3
Natural coverage can cover more than 2 percent of the landfill	0-1

TABLE V: Scores ranges of water wells density parameter

Number of wells within 8 km of the landfill	Scores ranges
Less than 5 wells	8-10
Less than 10 wells	6-8
Less than 15 wells	4-6
More than 20 wells	0-4

TABLE VI: Scores range of easy sampling of groundwater parameter

How to take samples of water	Scores ranges
Sampling is with no problem.	5-10
Hydrogeological situation is complicated because of the sampling.	2-5
It is complicated due to pollutants in water samples.	0-2

TABLE VII: Score ranges landscape of landfill

Type of the impact of landscape of landfill on surrounding natural environment	Scores range from
Landfill does not have any effect on the natural environment.	7-10
affects waste landscape in the natural environment in the basic local scale	7-4
affects waste landscape in the natural environment in the basic regional scale	4-3
affects waste landscape in the natural environment in the basic country scale.	

TABLE VIII: Scores ranges of ground water depth parameter

Underground water resources and its depth	Scores ranges
There is no underground water sources and the landfill in 800 meters away.	10-8
There are no underground water supplies beneath the landfill.	6-8
Groundwater level is deeper than 25 meters.	4-6
The depth of underground water level is over 15 meters.	0-4

TABLE IX: Scores range of landfill privacy parameter

Waste landfill privacy	Scores range
Privacy in all areas around the landfill is over 46 meters.	9-10
There is a privacy area of more than 33 meters in all areas around the landfill.	8-9
There is a privacy area of more than 33 meters in more than 50 percent in all areas around the landfill	5-7
There is a privacy area of more than 33 meters in more than 25 percent in all areas around the landfill	4-5
Features more than 33 meters from the landfill, there are around 25 percent.	3-4
There is a privacy area of more than 33 meters in less than 25 percent in all areas around the landfill	0-3

TABLE X: Scores range of the parameter of using landfill after its closing

Using state after its closing	Scores range
The use of the landfill after its closure will be required locally.	7-10
The use of landfill is added to the existing facilities and is compatible with them.	3-6
Use of landfill is incompatible with the environment.	0-3

TABLE XI: Scores range of urban areas parameter

Location of landfill compared to urban privacy	Scores range
Landfill is located in the city	8-10
Landfill is located within the area controlled by the city.	5-7
Landfill outside the city area is under control of city and human control is strong.	3-4
Landfill outside the city is under control of city and human control is weak in that area.	0-2

TABLE XII: Scores ranges of the parameter of limited road traffic

Type of road traffic restriction	Scores range
There is no limit to the landfill.	9-10
In order to access to 50% of routes leading to the landfill, there is no little restrictions.	8-9
Little limiting factors are available in all directions	7-8
In order to access to 50% of routes leading to the landfill, there is little restrictions	4-6
To access the landfill from all directions, there are serious limitations.	0-3

TABLE XIII: Scores range of parameter of the impact of landfill on road traffic

Type of impact of landfill on road traffic	Scores range
There is no traffic impact.	8-10
There is a limited traffic impact in area near the landfill.	6-8
There is limited impact on all routes leading to the landfill.	4-5
There is moderate traffic impact in local areas.	2-4
There are serious traffic impacts in local areas.	0-2

TABLE XIV: Scores range of the parameter of distance from the solid waste production center

Distance from the center of solid waste generation	Scores range
Landfill is located at a distance of 16 kilometers from the center of solid waste generation.	8-10
Landfill is located 32 km away.	6-8
Landfill is located 48 kilometers away.	5-6
Landfill is located at a distance of 64 kilometers.	3-4
Landfill is located at a distance of 80 kilometers.	1-2
Landfill is located at a distance of more than 80 kilometers.	0-1

TABLE XV: Scores range of the parameter of the ability to buy land

Possibility of land purchase	Scores range
Purchase possibility is high	8-10
There is the possibility of purchase.	5-7
Purchase possibility is low.	2-4
There is no purchase possibility	0-1

- *Data Analysis*

According to the given weights and scores, total score of the related location will be calculated in a local scale that will be compared with table XVI.

$S_A = W_1 R_1 + W_2 R_2 +$.....

S_A = A final total score for place A

W_1 = Weight of the first parameter (Table I)

R_1 = First parameter score (Table II to XV)

TABLE XVI: PARAMETERS OF TOTAL SCORE

314 -420	Appropriate
214 -314	Average
182 -214	Weak
0-182	Very weak

-*Preparation of final appropriateness map*

In order to prepare the final suitability map, the maps classified based on suitable, mid-suitable and unsuitable values, are placed on each other two by two and classified in ARC GIS9.2 software and using Raster Calculator command. Consequently, the final map will be prepared based on the above values.

RESULTS

Among criteria for selection of landfill in local scale, characteristics of areas that should be excluded in Rasht city include:

1) Slope range of the study area: The slope of the landfill is different in various parts of the city so that 4.39 ha. of land is with a slope of 0 -15 per cent, 3.72 ha. of land with a slope of 15-40%, and 1/66 ha. of land is with slope of more than 40 percent.

2) Historical and religious centers: Landfill is not near historical and religious centers and its distance from the nearest site is about 5.2 km.

3) Important environmental areas (sensitive habitat): Deylaman-Dorfak which is a hunting ban area is a sensitive habitat in the study area. This area is environmentally important and landfill is 10.3 km far from the landfill.

Results of other local criteria based on field observations of landfill site visits, interviews with experts and officials and using prepared maps are as follows:

1-Depth of appropriate soil for the landfill cover layers: Landfill soil is low and needs to be prepared from other areas.

2-Deep lands: In this area, natural deep lands are used for landfill.

3-Natural landfill in public view: Natural coverage of landfill is of forest type in Saravan and covers more than 25 percent of landfill.

4-Density of water wells: In order to evaluate this parameter, 8 km radius of the landfill was considered. There were 32 operating wells in this area.

5-Easy sampling of groundwater: Depth of groundwater level is high in this area. But it is rather complicated due to sampling.

6-Landscape: Landfill impacts on natural environment in local scale.

7-Depth of groundwater level: Depth of ground water is less than 15 meters.

8-Privacy of landfill: Privacy of landfill is more than 46 meters.

9-Using of the landfill after closing: After completion of landfill operations, creating of green space will be added to existing facilities and will be compatible with it.

10-Urban areas privacy: Rasht landfill is located outside the city privacy.

11- Areas with limited road traffic rules: There is little restriction to access the landfill.

12- Landfill impacts on traffic: There are serious and heavy traffic impacts on this route.

13- Distance from the center of solid waste generation: By using landfill location map of the city of Rasht (The main solid waste production) it was determined that this area is located within 23 km from the solid waste production center.
14-Ability to purchase land: Landfill has been not purchased land and there is no purchase possibility due to natural resources property. Table XVII provides valuation scores of landfill studied in the local scale.

TABLE XVII: Parameters studied in the local scale and their scores

Parameter	score
A – natural conditions	
Depth of appropriate soil for the landfill cover layers	2
Available deep land	0
Natural cover of landfill in public view	9
Density of water wells	1
Easy sampling of groundwater	1
Landscape of landfill	5
Depth of groundwater level	0
B - Land use	
Landfill privacy	10
Using landfill after its closing	5
Privacy of urban areas	1
Areas with limited road traffic	7
Landfill impact on traffic	7
C - Economical factors	
Distance from the solid waste production center	7
Ability to purchase land	1

Calculation of landfill scores in the local scale
According to Table XVII and their replacement in the formula, total score for the landfill at the local scale was calculated as 152. Thus the suitability of Rasht landfill in local scale was evaluated very weak.

DISCUSSION AND CONCLUTION

Rasht city has been growing due in the last 20 years because of two main phenomena of rural and urban areas connections and natural urban population that has increased more than twofold. Population growth in the city caused more solid waste production. This phenomenon due to lack of recycling process performance causes various economic, social, environmental and health problems. According to 620 tons of landfilling per day in the natural environment and causing surface and groundwater pollution, based on local screening method, it is possible to rank this location as 152 that show its weak values. The main reasons for the occurrence of this condition may be considered as land purchase ability, deep land, density of wells, and lack of ease of sampling and high groundwater levels that collectively accounted for 50 percent of parameters. This condition reveals that status of solid waste landfill of Rasht city is in a critical and undesirable situation. According to the results of this study we can recommend the following results:

1 – According to the increasing population of Rasht city in the coming years, completing of existing landfill capacity and the absence of favorable conditions, it is essential to find other options disposing of wastes.
2 – Rasht distance in the urban development process would be less than available location. In this situation, future concerns resulting from various infections, especially air pollution increases. Moreover, other small and large population centers such as villages of Jokolbandan, Kecha and etc. and their proximity to the existing landfill leads to worse conditions.
3 - It is essential to perform waste recycling, separation and reduction programs of hazardous waste such as hospital waste and industrial waste to prevent their discharge in the landfill.
4 - Reconstruction of forest areas within the landfill and preventing leachate from entering surface and groundwater with the implementation of engineering and health measures is one of the priorities for reconstruction and reducing inconsistent effects of present landfill that will be possible with environmental management.

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