Site Selection of Construction Waste Landfill Based on Combination of Fuzzy AHP and Geospatial Information System (GIS)

(Case Study: Qazvin, Iran)

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ABSTRACT

Today, with the increasing urban development, construction waste is a major problem for urban life. The city of Qazvin is no exception to this, and researching an optimum landfill site is an important necessity. The purpose of this research is to optimum site selection areas for landfill of Construction wastes using the geospatial information system (GIS) in a boundary area of Qazvin county which taking into account the terms and conditions of organizations such as the Municipality, Waste Management and Environmental Protection Organization. In this study, 16 layers of information including geology, soil type and permeability, landuse, climate, river distance, distance from protected areas, aspect, etc. in the boundary of Qazvin county were used. After producing the preliminary maps, the sub-criteria of each information layer are classified and evaluated and the values are converted to fuzzy values between zero and one. Then, fuzzy analytic hierarchy process (FAHP) method have been used to determine the absolute weight of each information layer and by integrating and overlapping weighted layers, suitability map of construction landfill site for Qazvin city is produced. According to the suitability map, sites for landfill were identified in five distinct zones and fields with high area among fields of fifth zone (with value 9) were suggested as the best landfill site for a 40-year period. The results showed that northwest of Qazvin due to good soil type, suitable landuse, distance from rivers, faults and access to communication road and dry climate could be the most suitable site for landfill.

KEYWORDS

Geospatial Information System (GIS), Fuzzy Analytic Hierarchy Process (FAHP), Construction Waste Landfill, Site Selection, Qazvin

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1. Introduction

The uncontrolled growth of the population has led to the increasing development of the construction industry and, as a result, the production of construction landfill. In Iran, according to daily statistics, about 200 to 250 thousand tons that means 70 to 80 million tons of construction landfill are produced annually [1].

In this study, in order to find suitable landfill construction site for Qazvin city some criteria such as geological information, soil science, topography, distance from population and industrial centers, distance from road lines and appropriate landuse have been employed. Due to the involvement of different criteria, in this study, the geospatial information system (GIS) was used, which has the ability to combine information and produce results. How to combine data and make decisions in the geospatial information system is so important that using fuzzy logic and analytic hierarchy process (AHP) together, because of its highly efficient nature, can bring many benefits that was used in this article. In 1992, Hendrix and Buckly Evaluated the proper site selection of the landfill in Vermont, USA, in terms of physical and economic characteristics using GIS [2]. In 2002, Shrivastava and Nathawat explored the location of landfills around the city of Ranchi using GIS and RS, taking into account various natural and human criteria [3]. In 2017, Won and Cheng began to model building information to build and manage the discharge of trash and reduce it [4]. In 2017, Ghanei and Kashfi started to locate the landfill of construction waste in Yazd city using the analytic hierarchy process method. In this study, they chose optimal sites for landfill using parameters such as geology, soil science, landuse and their composition in the GIS [5].

2. Methodology

The AHP method, which is based on the analysis of the human brain for complex problems, was proposed by a researcher named T. L. Saaty in the 1980s [6]. This technique is based on pairwise comparisons and allows researchers to study different scenarios.

analytic hierarchy process involves 5 key steps:

1. Establishing of hierarchical structure.
2. Establishing a pairwise comparison matrix.
3. Calculation of eigenvalue and eigenvector.
4. Perform compatibility tests and weight calculations.
5. The compatibility test examined whether the answers to the questionnaires are consistent or not.

However, the analytic hierarchy process method does not reflect accurately the human reasoning and perception, because this method uses determined numbers in pairwise comparisons. Fuzzy logic is able to provide mathematical formulation of many concepts and systems that are inaccurate and ambiguous, and allow for reasoning and decision-making in conditions of uncertainty [7]. The model of membership function of The fuzzy logic helps to scrutinize uncertainty and fuzziness in a way comparable to the human language. The phases of the fuzzy analytic hierarchy process method as “Chang’s method” are illustrated below [8]:

phase1. Stablish a hierarchical structure

phase2. Define fuzzy numbers in order to pairwise comparisons

phase3. Stablish a pairwise comparison matrix ($\tilde{A}$) using fuzzy numbers

$$\tilde{A} = \left[\tilde{a}_{ij} \right] \quad (1)$$

Where $a_{ij} = (l_{ij}, m_{ij}, u_{ij})$, l_{ij}, m_{ij} and u_{ij} represent lower limit, peak, and upper limit of triangular fuzzy numbers.

3. Discussion and Results

The general process of locating can be described in three main steps. The **first step** is to process and extract the effective parameters and factors in site selecting construction landfills. In the **second step**, the generated layers or maps are classified using the GIS tool and assign Saaty scale 1, 3, 5, 7 and 9 (from low level to high level) to classes according to the rules and conditions, and then the evaluated values are fuzzified. In the **third step**, the weights of layers or factors that are effective in site selection are determined by fuzzy analytic hierarchy process. By applying weights to the fuzzified layers and overlapping weighted layers, suitability map of construction landfill is produced. In this study, after preparing the suitability map, it is classified to 10 classes, that every two classes represent a single zone. Zone 5 is a perfect zone (by value of 9) to bury construction landfill. The main reason of being completely suitable zone (by value of 9) can be listed as follow: 1) reasonable distance from fault points 2) reasonable distance from rivers and protected areas 3) landuse type of poor and relatively poor rangeland lands 4) and dry climate. Also, the main reason for the inadequacy of completely

The main reason of being completely unsuitable zone (by value of 1) can be listed as follow: 1) short or so long distance from city area 2) short distance from fault points 3) agricultural and forestry landuse 4) less distance from rivers and having humid climate. As can be seen in Figure 1. zone 5 with value of 9 is masked from the other areas and zone 5 itself is divided into two regions with the first and second priority that has 140 and 303 square kilometers, respectively. Due to the dispersion proper area, three sites are proposed to bury construction

landfill. In selecting the proposed sites, parts of zone 5 were selected that were close to Qazvin city.

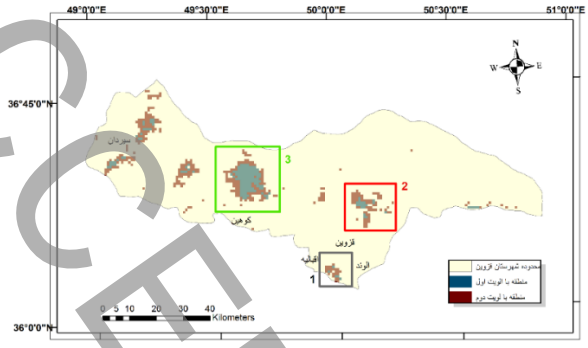

Figure 1. Three suggested sites for burying construction landfill in Qazvin city.

4. Conclusion

A series of layers were processed using ArcGIS software for site selecting of construction landfill. Shapefile layers (point, linear and polygon layers) and digital elevation model (DEM) as raster layer were called to the software to extract height, slope and aspect. Then, after applying Saaty scale to layers, they were fuzzified. In order to calculate the weight of the layers using the FAHP method, Excel software was used and the calculated weights have made effect on the final overlapped layer. Determining the prioritization of layers relative to each other is very important in the FAHP method. Based on the results of the present study, it was found that 29% of the city of Qazvin has a suitable or ideal condition for burying landfill. After the production of suitability map for site selecting and Qazvin city is divided to 5 zone area then, zone 5 (class 9th and 10th, which have high level in Saaty scaling), which is completely suitable, was selected for the burial place of construction landfill. The three proposed sites from zone 5, which were located near Qazvin city, were selected to have a value of 9 and a suitable distance from the cities (Alvand, Eghbaliyeh and Qazvin) and the villages. The third proposed site with the relative average of higher values rather than other two sites is first priority.

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