International Journal of Earth, Energy and Environmental Sciences
ISSN: 2517-942X
Vol:9, No:8, 2015

Selection of Solid Waste Landfill Site Using Geographical Information System (GIS)

F. Iscan, C. Yagci

***Abstract*—**Rapid population growth, urbanization and industrialization are known as the most important factors of environment problems. Elimination and management of solid wastes are also within the most important environment problems. One of the main problems in solid waste management is the selection of the best site for elimination of solid wastes. Lately, Geographical Information System (GIS) has been used for easing selection of landfill area. GIS has the ability of imitating necessary economic, environmental and political limitations. They play an important role for the site selection of landfill area as a decision support tool.

In this study; map layers will be studied for minimum effect of environmental, social and cultural factors and maximum effect for engineering/economic factors for site selection of landfill areas and using GIS for a decision support mechanism in solid waste landfill areas site selection will be presented in Aksaray/Turkey city, Güzelyurt district practice.

***Keywords*—**GIS, landfill, solid waste, spatial analysis.

I. Introduction

DOMESTIC or industrial wastes can cause very serious environment problems when they are not eliminated in a sanitary and healthy way. As it is not possible to avoid these wastes which are results of modern life, the best solution is to eliminate them by causing the minimum harm for the nature. Solid waste problems are the most important environmental problem of Turkey of late years. Amount of solid waste per person increases due to rapid population growth, urbanization and industrial operations. The issue of eliminating solid wastes in a healthy and economical way has gained more importance in last year's because solid wastes increase and irregular solid waste landfill areas are unhealthy [1]. If solid waste landfill areas are not selected carefully and built in proper technique, it can bring along no recoverable problems.

One of the methods of eliminating wastes with the minimum harm to environment is to store them regularly. Sanitary elimination of solid wastes, which is applied by most of the European Union countries, is done in a very unhealthy way in Turkey. For example; normally there must be a lot of criteria for site selection of landfill area of solid wastes, but in Turkey, this process is executed by a few people randomly and irregularly.

Today, it is possible to see the traces of technology in all areas. Technology, which is used in the base of almost every perfect project, can also be used in creating landfill areas and alternative solutions can be presented to users.

Developments in computer technologies increased the practicability of data storage, data arrangement, data sharing and reassessment of data and data analysis.

As the spatial information system users and dealers increase rapidly, technical staff and scientists, who research and produce with conventional techniques, have started to move towards these techniques.

Geographical Information Systems (GIS) are the main informatics function of 2000's. GIS, which saves the data in geographical coordinate connected relational database management system, has marked an era in associating and sharing data on earth.

One of the most successful application areas of GIS, which enables analysis and ease making right decisions according to these analyses, is the solution of environmental problems. Using GIS for the solution of solid waste landfill site selection, which is one of the developing environmental problems in parallel with increasing population, will be extremely possible and logical.

Solid waste site selection of such "land usage planning" includes a lot of spatial analyses such as distance to different land usage areas (buffer zone), angle of gradient and reclassification for conformity. In this sense, Geographical Information Systems (GIS) which are of the ability of processing and analyzing each kind of data, are of an important role for proper landfill areas; in a word a decision support tool for determining alternative areas. Such as GIS makes it possible to include all kind of spatial technical, economic and social conditions and studying the results developed under different conditions. But another important question in landfill site selection process is to find out the more proper alternatives among the proper landfills. Multi Criteria Decision Analysis (MCDA) gives the opportunity of determining (ordering) alternative areas for decision factors with scoring system [2]-[6].

A lot of criteria must be considered in a very short time while searching landfill areas. This can be achieved by GIS [7].

Key element of the site selection process and system to be applied are basic criteria. Criteria which are used in site selection studies are two types: 1- Limitations, 2- Decision Factors.

Limitations are the restrains which determine if the evaluated areas are (1) proper (2) or not proper [8], [9]. For example these assessments are limitations as it is not possible

F. I. is with the Department of Geomatics, Univesity of Selcuk, Konya, Turkey (corresponding author to provide Phone: +903322231912; Fax: +90332410635; e-mail: fiscan@ selcuk.edu.tr).

C. Y. is with the Department of Geomatics, Univesity of Selcuk, Konya, Turkey (e-mail: cerenavci@ selcuk.edu.tr).

to make landfill areas to settlements, agricultural areas or water surface areas.

Decision factors are criteria which increase (high point) or decrease (low point) the suitability of alternatives by scoring [8]. In other words, factors define a gradational suitability for the smallest suitability and maximum suitability rate for that factor. For example, distance to settlement areas factor and 1000meter distance is 0 point with the smallest suitability rate; 5000 meter and longer distances can be defined as 1 point as the most suitable areas. According to this, a distance between 1000 meter and 5000 meter gets 0-1 point [10], [11].

Weighted Linear Combination method is used for calculating appropriateness of each alternative in the final step of solid waste landfill site selection decision support system by using appropriateness map and final points required in decision analysis.

Reference [12] stated that GIS and multi criteria techniques can be used together in site selection for landfill areas. Reference [13] made a site selection in a study in Macedonia using overlay technique for the site selection of a new landfill area by GIS as the decision support system, and in the second step they have chosen the best alternative by using environmental and economic factors.

A lot of studies are done for site selection of solid wastes landfill areas by using fuzzy logic and Analytical Hierarchy Process (AHP) with GIS [14]-[20].

In this study, limitations such as distance to city center, closeness to water wells, irrigation channels, roads, distance to protection and forest areas and slope of the land are used for site selection of Aksaray city, Güzelyurt district solid waste landfill areas. A final map is produced for the study area and the best areas are determined for landfill area.

II. Material and Method

A. Application Area

In this study, the case study was made for the county of Güzelyurt which is a town and district of Aksaray Province in the Central Anatolia region of Turkey, at a distance of 45 km from the city of Aksaray (Fig. 1). According to 2013 census, population of the district is 12,600. The district covers an area of 322 $km^2$and the average elevation is 1,485 m. This is an area of great natural beauty and historical importance, part of the ancient region of Cappadocia, near the much-visited Ihlara Valley.

The daily average waste collection for Güzelyurt Municipal Council is about 16 tons which yields about 5,840 tons of wastes annually. Land requirement for the Güzelyurt district is calculated as 29,200 m^2 (2.9 ha) for a 20-year disposal period.

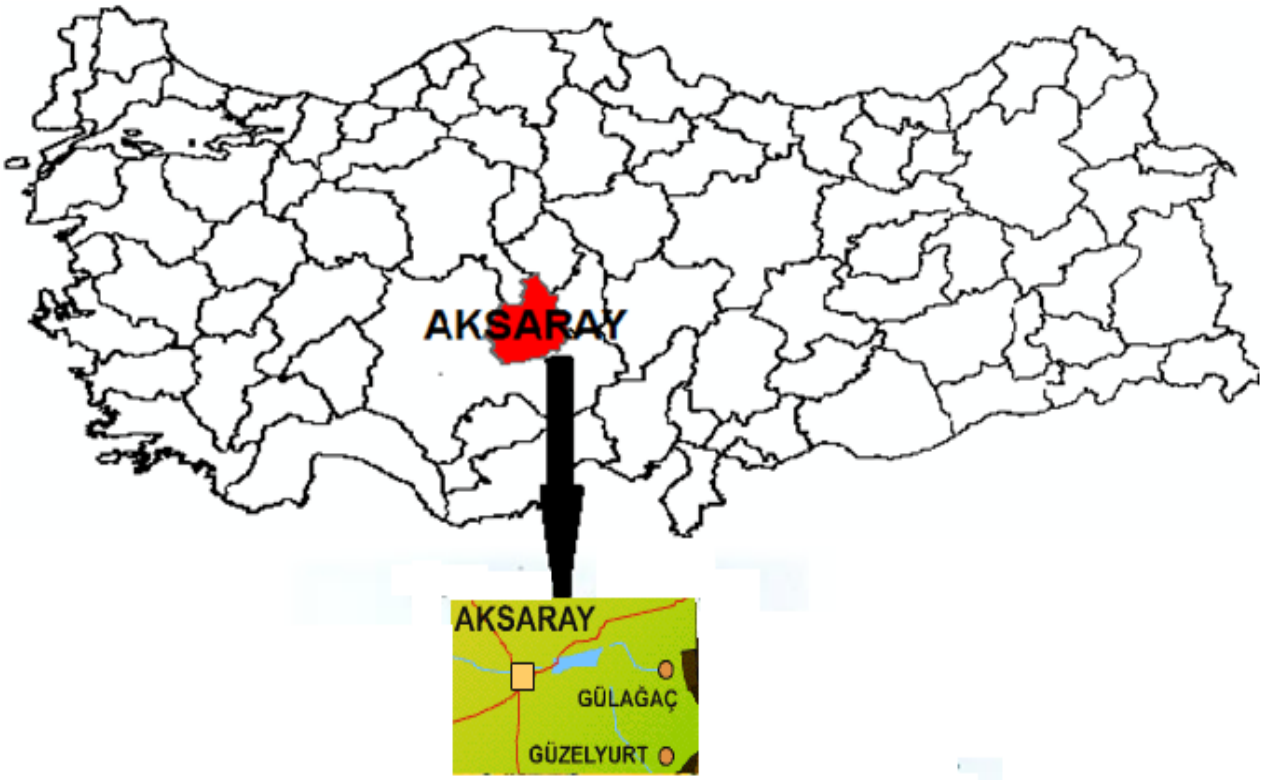

Fig. 1 Study area

B. Technique

Aksaray-L32-b3 and Aksaray-L32-b3 named 1/25 000 scaled analog maps are digitised by using NETCAD software. Environmental, social and cultural factors and engineering/economic factors should be considered for site selection of landfill areas. In this study; river system, wildlife protection areas, historical and important cultural areas, urban development areas, highway networks, slope and railway network factors are considered. These factors are transferred into information system separately by using ArcGIS software.

Map layers are created by buffer area analyses which are done for each numerical factor. Buffer area distance is chosen by considering legislative regulations in Turkey, applications abroad and characteristics of the area. Then overlay analysis is applied and alternative areas are chosen for landfill area of solid wastes.

III. Application

A. Digitized Map Sheet of Application Area

Map sheet which are in application area (Aksaray-L32-b3, Aksaray-L32-b3) are scanned in A0 scanner and digitised in NETCAD software. Digitised map sheet are transferred into information system software ArcGIS for executing necessary analyses (Fig. 2).

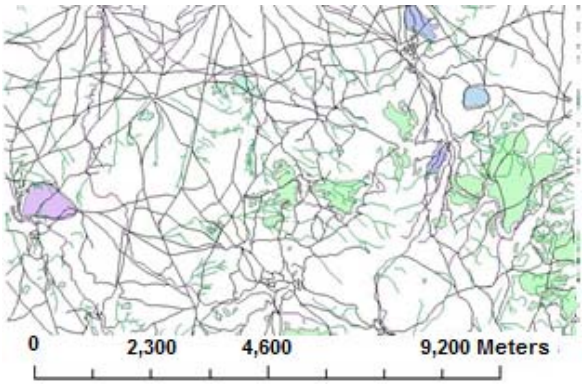

Fig. 2 Digitizing map sheet

B. Map Features and Property Points

Limitations which are done for site selection of landfill areas are achieved by total feature points of minimum and maximum map layer weights. Total weights of the maps should be 100% for a meaningful and consistent printed map. Limitations of the map are considered equally. Each of them is weighted as 14% equally. Property points of solid waste landfill areas are given in Table I.

C. Analyses of Buffer Areas and Overlapping Areas

A buffer distance is determined (200m, 1000m etc.) for each layer by considering related legal legislations or properties of the buffer area analysis. Map layers are created for each layer with buffer area analysis according to criteria given in Table I. Buffer analysis of road layer is shown in Fig. 3. Also slope map of the study area is given in Fig. 4. Possible alternative landfill areas determined by applying overlay analysis after buffer analyses. Property point of 10 indicates the most improper places and 0 value indicates the most suitable places. If the distance of landfill areas to irrigation channels is shorter than 100 meters, then the weight is 10, if it is further than 100 meters then the weight is 0. After the studies suitability map is acquired for the study area and the most suitable areas are determined for Güzelyurt district (Fig. 5).

TABLE I
Property Points Used in Site Selection of Landfill Areas

Layer	Point	Layer	Point	Layer	Point
Urban		Roads		Wells	
<1 km	10	<0.2 km	10	<300 m	10
1-2 km	1	0.2 km-1 km	0	300-500 m	5
2-3 km	2	1-2 km	1	>500 m	0
3-4 km	3	2-3 km	2		
4-5 km	4	3-4 km	3	Archeological Sites	
5-6 km	5	4-5 km	4		
6-7 km	6	5-6 km	5		
7-8 km	7	6-7 km	6	0-500 m	10
8-9 km	8	7-8 km	7	>500m	0
9-10 km	9	8-9 km	8	Surface Waters	
>10 km	10	9-10 km	9	<100 m	10
Forest		>10 km	10	>100 m	0
<5 km	10			Slope of Land	
>5 km	0			> %15	10
				< %15	0

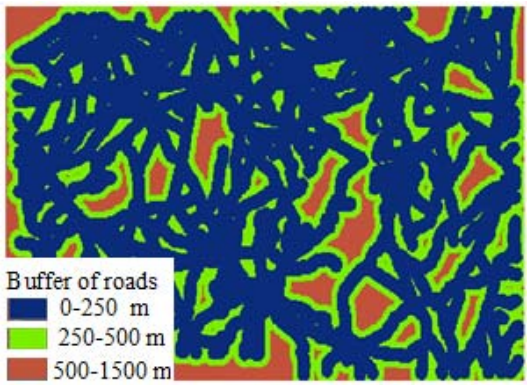

Fig. 3 Buffer analysis of road layer

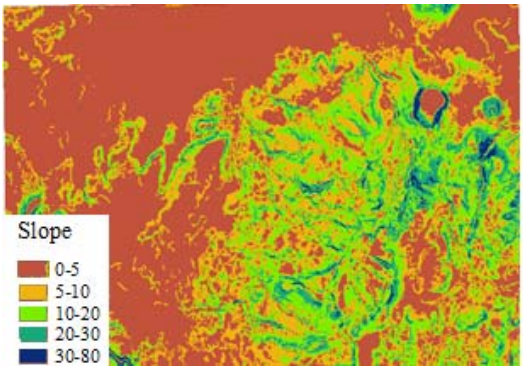

Fig. 4 Slope map of the study area

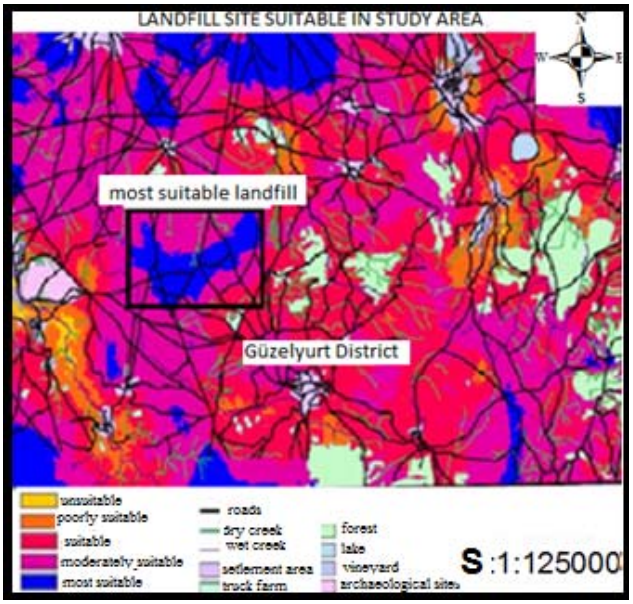

Fig. 5 Landfill site suitability in study area

IV. Results and Conclusions

In this study, solid waste landfill site selection analysis is done for Aksaray/Güzelyurt district. In the study, each layers are weighted equally. But system planner allows uniting of each layer in changing significance level. According to analyses it is determined that dark blue marked areas are suitable for solid waste landfill areas and yellow marked areas are not suitable places. Considering surrounding settlement positions, transportation and cost of the study area, it is determined that solid waste landfill area should be south west of Güzelyurt district.

Site selection process of a solid waste landfill area requires assessment of a lot of factors, which are mostly spatial information, and criteria. Local managements generally complete this process without sufficient budget or consulting experts and this causes a great deal of environmental pollution. Especially, GIS is an important tool for determining the site for landfill areas. Also it is practical and economical. Using GIS in solid waste landfill site selection process gives more acceptable areas and it can also make more economical site selections.

Acknowledgment

This paper is supported by Selcuk University, Scientific Research Projects Coordination Unit, Project Nr. 15701449.

References

[1] M.I. Yeşilnacar, Y. Bayındır, S. Uyanık, O. Demir, A. Kirikçi. "Population Estimation and Quantity Determination of Solid Waste for the GAP provinces". University of Dokuz Eylul, Department of Environmental Engineering and III. National Congress on Solid Waste, 25-27 Mayıs 2005, Izmir, pp. 119-129.(in Turkish)

[2] M.Z. Siddiqui, J.W. Everett, B.E. Vieux. "Landfill Siting using Geographic Information Systems: A Demonstration". Journal of Environmental Eng., 122(6), 1996, pp. 515-523.

[3] A. Allen, G. Brito, P. Caetano, C. Costa, V. Cummins, J. Donnelly, S. Koukoulas, V. O'Donnell, C. Robalo, D. Vendas. "A Landfill Site Selection Process Incorporating GIS Modelling". Proceedings of the Ninth International Waste Management and Landfill Symposium, Sardinia, 2003, Cagliari, Italy.

[4] J. J. Kao. "A Raster-based C Program for Siting a Landfill with Optimal Compactness". Computers&Geoscience, 22 (8), 1996, pp. 837-847.

[5] H. Y. Lin, J. J. Kao. "A Vector-based Spatial Model for Landfill Siting". Journal of Hazardous Materials, 58, 1998, 3-14.

[6] M. J. S. Baban, J. Flannagan."Developing and Implementing GIS-assisted Constraints". Planning Practice&Research, 13 (2), 1998, pp. 139-151.

[7] G. Dorhofer, H. Siebert. "The Search for Landfill Sites-Requirements and Implementation in Lower Saxony, Germany", Environmental Geology 35 (1), 1998, pp. 55-65.

[8] J. R. Eastman. "IDRISI - Guide to GIS and Image Processing". ClarkLabs, Clark University, USA, 2003.

[9] M. Klein, L. B. Methlie. "Knowledge-based Decision Support Systems with Applications in Business". John Wiley&Sons, 1995.

[10] M. N. Alpaslan. "Planning Landfill, Solid Waste Management Seminar", Alpaslan, M.N. (Editor), Union of Chambers of Turkish Engineers and Architects, Chamber of environmental Engineers, Izmir Branche,2005. (in Turkish)

[11] H. Sarptaş. "Implementation of Decision Support System for Landfill Sites". Phd. Thesis, University of Dokuz Eylül, Graduate School of Natural Sciences, Environmental Engineering, 2006. (in Turkish).

[12] G. Higgs. "Integrating Multi-Criteria Techniques with Geographical Information Systems in Waste facility Location to Enhance Public Participation", Waste Management Research, Vol.24, 2006, pp.105-117.

[13] K. Vatalis, O. Manoliadis, "A two-level multi-criteria DSS for Landfill Site Selection Using GIS: Case Study in Western Macedonia, Greece", Journal of Geographic Information and Decision Analysis, Vol.6, No.1, 2002, pp.49-56.

[14] B. Nas, T. Cay, F. Iscan, A. Berktay. "Selection of MSW landfill site for Konya, Turkey using GIS and multi-criteria evaluation", Environmental Monitoring and Assessment, 160, 2010, pp.491–500.

[15] V. Yildirim. "Application of raster-based GIS techniques in the siting of landfills in Trabzon Province, Turkey: A case study", Waste Management & Research, vol. 30, no. 9, 2012, pp. 949-960.

[16] A. Aydi, M. Zairi, H. Ben Dhia. "Minimization of environmental risk of landfill site using fuzzy logic, analytical hierarchy process, and weighted linear combination methodology in a geographic information system environment", Environmental Earth Sciences vol. 68, no. 5, 2013, pp. 1375-1389.

[17] G. P. Yal, H. Akgun. "Landfill site selection and landfill liner design for Ankara, Turkey", Environmental Earth Sciences, vol. 70, no. 6,2013, pp. 2729-2752.

[18] V. F. Nascimento, A. M. da Silva. "Identifying problems for choosing suitable areas for installation of a new landfill through GIS technology: A case study", Journal of the Air & Waste Management Association, vol. 64, no. 1, 2014, pp. 80-88.

[19] O. E. Demesouka, A. P. Vavatsikos,K. P. Anagnostopoulos."GIS-based multicriteria municipal solid waste landfill suitability analysis: A review of the methodologies performed and criteria implemented". Waste Management & Research, vol. 32, no. 4, 2014, pp. 270-296.

[20] O. Arkoc. "Municipal solid waste landfill site selection using geographical information systems: a case study from Corlu, Turkey", Arabian Journal of Geosciences, vol. 7, no. 11, 2014, pp. 4975-4985.

FatihIscan is an Assoc. Prof. Dr. of Geomatic Engineering at the Selcuk University of Konya, Turkey. He has been with Selcuk University since 2000. He completed his PhD study at Selcuk University (2009), in "Application of Fuzzy Logic in Land Consolidation Activities" subject. He has an MSc from Selcuk University, Department of Geomatic Engineering (2003), and a BSc from Yildiz Technical University (2000), in Geomatic Engineering. His research interests; Land consolidation, public works, cadastre law and GIS.

CerenYagcı was born in Eskişehir/Turkey. She received her BS degree in Geomatics Engineering from Selcuk University, and her MS degree in Geomatics Engineering from Selcuk University and also, she started her PhD studies in Geomatics Engineering from Selcuk University in 2014.