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Combining GIS and AHP models for landfill site selection in Niğde, Turkey

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Abstract

Nowadays, the quick development of technology and the increase in migration from rural areas to urban areas have transformed cities into populous living places. With the increasing population, urbanization ratio and changing consumption habits, natural environment and energy problems are expanding in cities. These problems that arise in the cities not only negatively affect the economic and social life, but also affect the welfare of the people living in the city and bring many problems for local governments. With the unplanned urbanization and the environmental problems, solid waste landfill sites have started to stay within the settlement areas. GIS and MCDM have become an effective and important tool in solving environmental and spatial problems as well as in many other problems. With the integration of GIS and MCDM, suitable site selections can be made in terms of economic and environmental aspects. For this purpose, in this study; Solid waste landfill site selection study was carried out for Niğde province by using Analytical Hierarchy Method (AHP) and Geographic Information Systems (GIS). In this context, 9 evaluation criteria such as elevation, slope, geology/lithology, land use, proximity to roads, distance to settlements, protected areas, rivers and water surfaces were used to determine potential solid waste landfill areas.

1. Introduction

Undesirable materials that consist in all fields of life and arise as a result of human and other activities, which cannot be completely removed, but can be disposed of in the best possible way with various methods and efforts, are defined as solid waste (Işıldar, 2018). The increase in human population and related human activities in developing countries has expedited urbanization (Sumathi et al. 2008). As a result of increasing population, migration from rural areas to cities, changes in consumption patterns, economic growth, increase in income, urbanization and industrialization, solid waste production and its diversity have increased and the negative effects of this rapidly increasing waste on the environment have turned into a problem that cannot be neglected (Aydın, 2007, Ngoc and Schnitzer, 2009; Güler and Yomralıoğlu, 2017).

Urban solid waste management, which is an environmental issue, is a sensitive area in the world countries and can be described as the try to dispose of wastes with the optimum method that does not damage the environment, aid by the local community that straightly under effect of the solid waste program in the region (Güler, 2016; Işıldar, 2018). Inappropriate solid waste management can cause significant health and environmental issues. Therefore, in order to avoid such issues, solid waste disposal methods and environmental effects should be handled sensitively in the solid waste management (Karagiannidis and Moissiopolous, 1997; Pires et al. 2010; Şener et al. 2010; Bilgilioğlu et al. 2022).

Solid waste management system is a complex and multidisciplinary problem that thoroughly examines technical, social and economic factors in terms of recycling and sustainability. Site selection studies for a solid waste landfill is a complicated process that requires the processing of large amounts of spatial data. While determining the site selection criteria; In general, restrictive parameters such as land cover, geological formation, administrative borders, surface waters, highway are used (Sadek et al. 2006; Şengün et al. 2018; Ciritçi and Türk, 2019). The integration of rapidly developing Geographic Information System (GIS) and MCDM models is a suitable method in studies that require appropriate site selection and similar spatial analysis. The GIS-based MCDM approach provides important contributions to decision makers in making

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appropriate site selection decisions, in terms of better understanding the problem, identifying the risks to be encountered and interpreting the results (Chen et al. 2001; Bilgilioğlu, 2022).

Within this scope of study; using the Geographical Information Systems (GIS) and Analytical Hierarchy Method (AHP), which is one of the and multi-criteria decision making (MCDM) methods, the appropriate location for the solid waste disposal site and the suitability of the existing solid waste storage area were investigated in Niğde province. For this purpose, 9 criteria were used in the determination of potential solid waste disposal sites, including elevation, slope, geology/lithology, land use, proximity to roads, distance from settlements, protection areas, rivers and water surfaces.

2. Method

MCDM is a tool that consent to determine the best choice between the criteria that are evaluated more than one and simultaneously. The purpose of using MCDM methods is to make the decision-making mechanism easy and fast in situations where the number of options and criteria is high (Huang et al. 2011; Rezaeisabzevar et al. 2020). With the progression of Geographic Information Systems (GIS), different MCDM methods have found application in solving spatial problems. These methods offer a broad field of applications like, land suitability mapping, site selection studies, planning in urban and regional scale. (Uyan and Yalpır, 2016).

Among the many MCDM methods used, which model selection will be most appropriate and which model is the most suitable for the decision maker depends on the issue to be solved (Uyan, 2011). AHP is an effective approach to decision making and is definitely the most widely used MCDM method. (Dehe and Bamford, 2015). AHP, used as a decision analysis tool, is a mathematical method evolved by Saaty in 1970s as a model to analyze complex decision problems with multiple criteria (Saaty, 1980). In this study, in order to determine the most suitable location for the solid waste disposal site, the evaluation criteria were weighted using the Analytical Hierarchy Process (AHP) technique, which is one of the MCDM techniques and is frequently used in the literature.

2.1. Study area

Niğde is located in the southeast of Turkey's Central Anatolia Region and its altitude is 1,229 m above sea level. Niğde province, whose neighboring provinces are Aksaray, Kayseri, Nevşehir and Konya, is separated from the province of Mersin by the Bolkar Mountains in the south, and from the province of Adana by the natural borders formed by the Aladaglar in the southeast and east (Figure 1; Soydan 2021).

Thermal resources, archaeological sites, rich historical texture, natural beauties, mountain and winter tourism opportunities are important factors that make the city a tourism center. Niğde Province has a population of 363,725 in 2021 and has an area of approximately 7312 km^2. Central Anatolia's typical continental climate is also seen in Niğde province (SERM 2020).

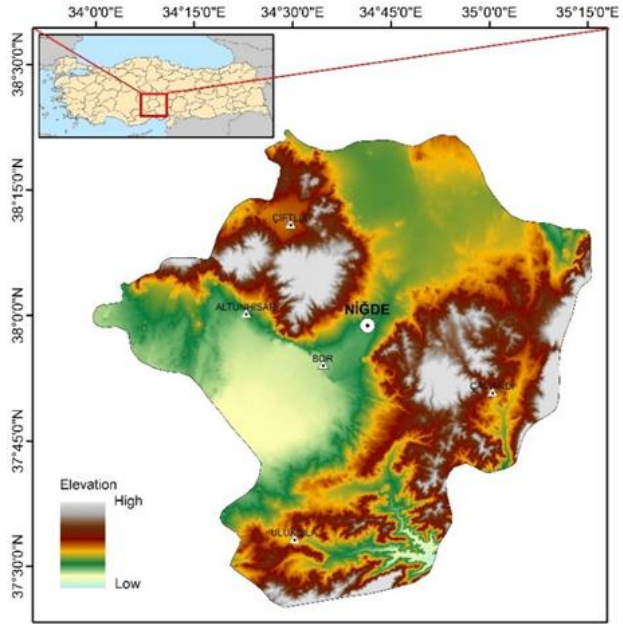

Figure 1. Study area

3. Results and Discussion

Comparison matrix for all criteria was created and the values obtained by calculating the importance levels of the criteria using AHP are given in Table 1. The pairwise comparison matrix was obtained using the opinions of experts in the field and previous literature studies. Since the Consistency Ratios (CT) obtained in the comparison matrices created in the AHP (0.0437) were below the desired value (0.10), the comparisons were considered to be consistent. All the data used in the evaluation were converted to the UTM 36-3 projection coordinate system and the pixel size was taken as 20 m in the study.

Table 1. Criteria weights

Criteria	Weight
Elevation	0.051
Slope	0.162
Lithology	0.130
Land use	0.074
Proximity to roads	0.091
Distance from settlements	0.114
Distance from protection areas	0.032
Distance from rivers	0.158
Distance from water surfaces	0.188

The criteria weights given in Table 1 show the importance of these criteria at the suitable site selection process. In this context, it has been determined that the criteria of Distance from water surfaces, rivers and slope are more important in the selection of landfill site selection, while the criteria of Distance from protection areas, elevation and lands use are less important.

The maps of each normalized criteria are given in Figure 2. In Figure 2, the areas shown in red represent very low suitable areas for the solid landfill disposal site, while the areas shown in dark blue indicate very high suitable areas.

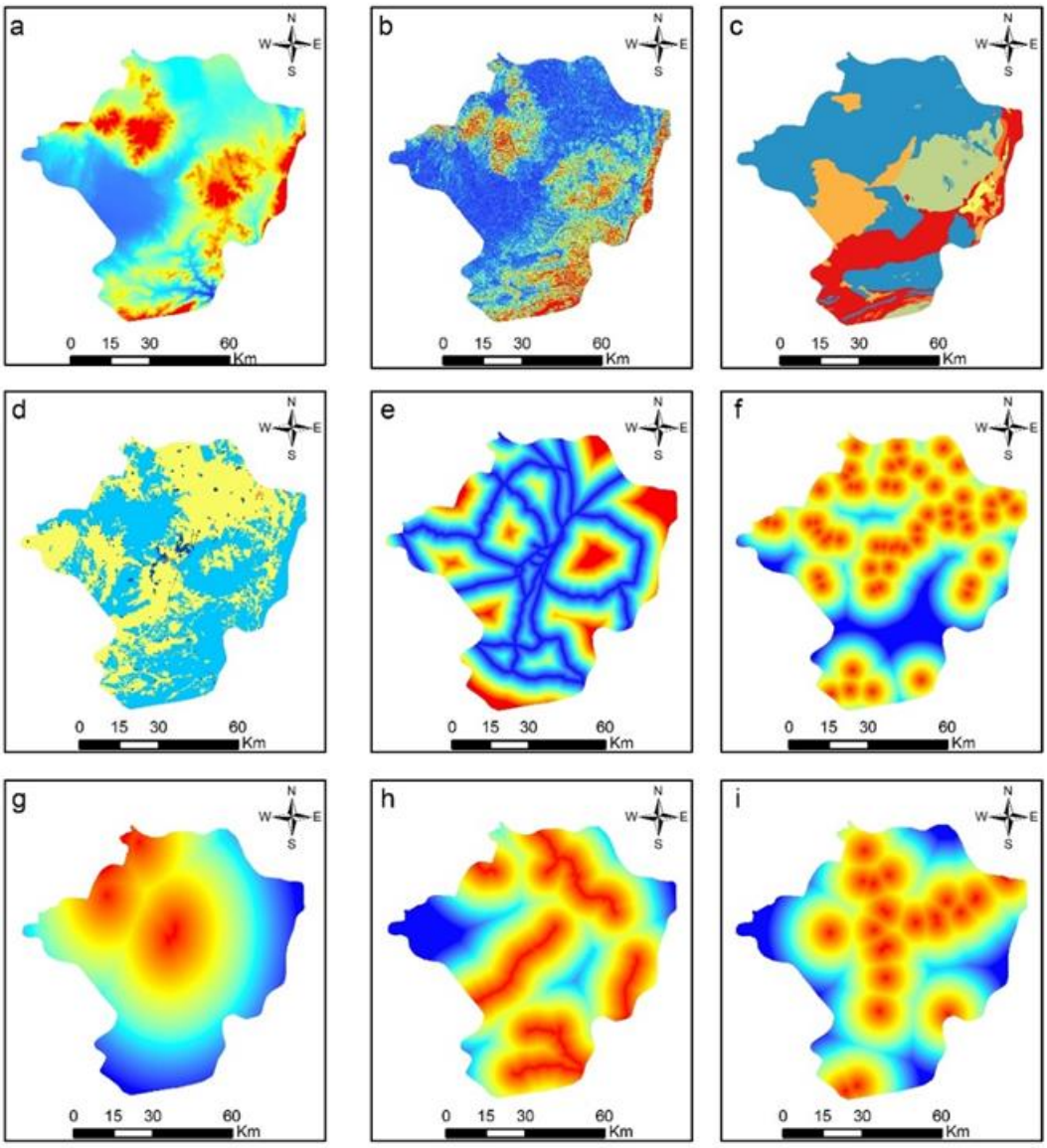

Figure 2. Evaluation criteria; a) Elevation b) Slope c) Lithology d) Land use e) Proximity to roads f) Distance from settlements g) Distance from protection areas h) Distance from rivers i) Distance from water surfaces

According to the analysis result, the study area; classified into 5 classes as very low suitable, low suitable, moderate suitable, high suitable and very high suitable and are shown in Figure 3. It is seen that central districts such as Altunhisar and Çamardı are more suitable areas for the construction of solid waste landfill sites compared to other regions. In addition to this, the existing solid waste storage facility in Niğde is located in a region that is considered very low suitable and low suitable according to the findings obtained from this study. This facility, which started its operations in 2013, is located in an area very close to the city with the expansion of Niğde province over the years. The study conducted by Ertunç et al. (2019), it is determined that the existing solid waste landfill site can affect the urban area negatively. Therefore, when the findings obtained from this study are compared with other similar studies (Öcal, 2010; Ertunç et al. 2019) carried out in the region, it is seen that the results are similar to each other.

4. Conclusion

In this study, site selection analyzes were carried out by combining GIS and AHP methods to obtain potential solid waste landfill sites in Niğde city. For this purpose, nine criteria were selected for the site selection study and after determining the weights of these criteria with the aid of AHP method, a suitability map was created. When the produced suitability map is examined, it has been determined that the city center of Niğde and existing solid waste facility is located in very low suitable area and the districts of Altunhisar and Çamardı are more suitable areas for the new facility to be constructed.

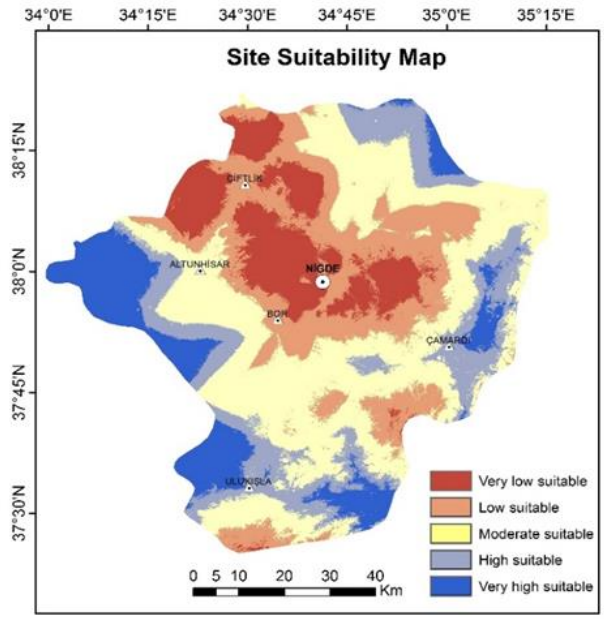

Figure 3. Solid waste landfill site suitability map of Niğde city

References

Aydın, N. (2007). Katı atık yönetiminde optimal planlama için bulanık doğrusal programlama yaklaşımı,MS thesis, Yıldız Technical University, İstanbul.

Bilgilioğlu, S. S. (2022). Coğrafi Bilgi Sistemleri ve Bulanık Analitik Hiyerarşi Süreci ile Elektrikli Araç Şarj İstasyonu Yer Seçimi. Afyon Kocatepe Üniversitesi Fen Ve Mühendislik Bilimleri Dergisi, 22(1), 165-174.

Bilgilioglu, S. S., Gezgin, C., Orhan, O., & Karakus, P. (2022). A GIS-based multi-criteria decision-making method for the selection of potential municipal solid waste disposal sites in Mersin, Turkey. Environmental Science and Pollution Research, 1-17.

Chen, K., Blong, R., & Jacobson, C. (2001). MCE-RISK: integrating multicriteria evaluation and GIS for risk decision-making in natural hazards. Environmental Modelling & Software, 16(4), 387-397.

Ciritci, D., & Türk, T. (2019). Alternatif katı atık depolama alanlarının analitik hiyerarşi süreci ve coğrafi bilgi sistemleri ile otomatik olarak belirlenmesi: Sivas ili örneği. Jeodezi ve Jeoinformasyon Dergisi, 6(1), 61-74.

Dehe, B., & Bamford, D. (2015). Development, test and comparison of two Multiple Criteria Decision Analysis (MCDA) models: A case of healthcare infrastructure location. Expert Systems with Applications, 42(19), 6717–6727.

Ertunç, E., Bozdağ, A., & Gökçek, Ö. B. (2019). Investigation of The Solid Waste Landfill Site selection Using The Geographic Information System In The City Of Niğde. Konya Mühendislik Bilimleri Dergisi, 7(4), 822-838.

Güler, D., & Yomralıoğlu, T. (2017). Coğrafi bilgi sistemleri ve analitik hiyerarşi yöntemi ile düzenli deponi yer seçimi: İstanbul ili örneği. Afyon Kocatepe Üniversitesi Fen ve Mühendislik Bilimleri Dergisi, 17(4), 262-269.

Güler, D. (2016). Analitik Hiyerarşi Yöntemi Ve Coğrafi Bilgi Sistemleri İle Alternatif Katı Atık Düzenli depolama Alanı Yer Seçimi: İstanbul İli Örneği. DR. Thesis, Istanbul Technical University, Istanbul.

Huang, I. B., Keisler, J., & Linkov, I. (2011). Multi-criteria decision analysis in environmental sciences: ten years of applications and trends. Sci. Total Environ. 409, 3578–3594.

Işıldar, A. (2018). Çok kriterli karar verme yöntemleriyle katı atık bertaraf yöntemi seçimi. MS thesis, Pamukkale Üniversitesi, Pamukkale (in Turkish).

Karagiannidis, A., & Moissiopolous, N. (1997). Application of electre III for the integrated management of municipal waste in the Greater Athens Area, European Journal of Operational Research, 97, 439- 449.

Ngoc, U. N., & Schnitzer, H. (2009). Sustainable solutions for solid waste management in Southeast Asian countries. Waste Management, 29, 1982–1995.

Öcal, T. (2010). Günümüz şehirleşme sürecinde evsel katı atık sorununa bir örnek: Niğde Şehri . Türk Coğrafya Dergisi, 55, 35-43.

Pires, A., Martinho, G., & Chang, N. B. (2011). Solid waste management in European countries: A review of systems analysis techniques. Journal of environmental management, 92(4), 1033-1050.

Rezaeisabzevar, Y., Bazargan, A., & Zohourian, B. (2020). Landfill site selection using multi criteria decision making: Influential factors for comparing locations. Journal of Environmental Sciences, 93, 170-184.

Saaty, T. L. (1980). The analytic hierarchy process. McGraw-Hill, New York.

Sadek, S., Fadel, M. E., & Freiha, F. (2006). A Multi-Criteria Modular and Flexible decision aid tool for Landfill Siting using GIS. 21st International Conference on Solid Waste Technology and Management, Philadelphia, USA. 26 - 28 Mar 2006.

Şener, Ş., Şener, E., Nas, B., & Karagüzel,, R. (2010). Combining AHP with GIS for landfill site selection: a case study in the Lake Beyşehir catchment area (Konya, Turkey). Waste management, 30(11), 2037-2046.

Şengün, M. T., Siler, M., & Engin, F. (2018). Katı Atık Depolama Alanlarının Yer Seçiminde CBS'nin Kullanımı: Malatya Örneği. Zeitschrift für die Welt der Türken/Journal of World of Turks, 10(1), 159-180.

SERM (2020) State of environment report of Niğde province. Republic of Turkey, Ministry of Environment and Urbanization

Soydan, O. (2021). Solar power plants site selection for sustainable ecological development in Nigde, Turkey. SN Applied Sciences, 3(1), 1-18.

Sumathi, V. R., Natesan, U., & Chinmoy, S. (2008). GIS based approach for optimized siting of municipal solid waste landfill. Waste Management, 28, 2146–2160.

Uyan, M., & Yalpır, Ş. (2016). Çok kriterli karar verme modeli ve CBS entegrasyonu ile tıbbi atık sterilizasyon tesislerinin yer seçimi. Afyon Kocatepe Üniversitesi Fen ve Mühendislik Bilimleri Dergisi, 16(3), 642-654.

Uyan, M. (2011). Arazi Düzenlemesi Çalışmalarında Mekansal Karar Destek Sistemleri Kurulumu ve Uygulaması. DR thesis, Selçuk University, Konya, Turkey.