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Araştırma Makalesi / Research Article

An Application For Solid Waste Site Selection in Kars Province

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Abstract

In order to control environmental pollution caused by solid wastes needs to be stored properly. In this study, SWARA which is a Multi Criteria Decision Making method was used to determine solid waste site selection criteria in Kars Province and criteria weights were determined by SWARA. Also MOORA method was used to select the most suitable solid waste site. As a result of this study, it has been determined that the importance of solid waste landfill site selection criteria are "Natural Life Protection Areas", "Land Costs", "Population Density", "Soil and Geology Structure", "Distance to Urban Areas". On the other hand, it has been determined that the least caretakers are "Slope", "River Network", "Road Network", "Underground Water Conservation Areas", "Historical and Important Cultural Areas". In order of the optimal solid waste location selection, A4 alternative in Kars province has been the optimal solid waste location.

Keywords: Solid waste, Site selection, SWARA, MOORA.

Katı Atık Yer Seçimi İçin Kars İlinde Bir Uygulama

Öz

Katı atıkların neden olduğu çevre kirliliğini kontrol etmek için uygun şekilde depolanması gerekmektedir. Bu çalışmada Kars İlinde katı atık yer seçimi kriterlerinin belirlenmesinde Çok Kriterli Karar Verme yöntemi olan SWARA kullanılmış ve kriter ağırlıkları SWARA ile belirlenmiştir. Ayrıca en uygun katı atık sahasının seçiminde MOORA yöntemi kullanılmıştır. Yapılan çalışma sonucunda katı atık depolama yer seçimi kriterlerinden en önemlileri sırası ile "Doğal Yaşamı Koruma Alanları", "Arazi Maliyetleri", "Nüfus Yoğunluğu", "Toprak ve Jeoloji Yapısı", "Kentsel Alanlara Uzaklık" olduğu belirlenmiştir. Öte yandan en az öneme sahip kriterlerin ise sırasıyla "Eğim", "Akarsu Ağı", "Yol Ağı", "Yeraltı Suyu Koruma Alanları" ve "Tarihi ve Önemli Kültürel Alanlar" olduğu belirlenmiştir. En uygun katı atık yeri seçimi sırasına göre, Kars ilinde A4 alternatifi en uygun katı atık yeri olmuştur.

Anahtar Kelimeler: Katı atık, Yer seçimi, SWARA, MOORA.

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1. Introduction

The proportion and diversity of solid wastes resulting from people's household are increasing. Because of the social and industrial activities, population growth, rising living standards and technological improvements. With the increase of solid wastes, the air, soil and water pollution that they form after the disposal methods cause significant environmental and health problems all over the world. Especially in big cities, as a natural consequence of conurbation, the problem of solid waste is growing rapidly. In order to prevent this, it is necessary to collect, transport, store and evaluate solid wastes efficiently and regularly and to make them harmless. On the other hand, solid waste disposal areas planned outside the residential areas in the past have remained in the residential areas over time.

In this study, it was aimed to determine the criteria for solid waste site selection in Kars. For this purpose, in the first part of the study, studies on solid waste site selection are examined, In the second part, information about the SWARA method has been given and in the next part, the application part of the study has started. In the third section, the method of the study was applied to the problem and the study was completed with the results section with suggestions for future studies.

2. Literature Review

Nowadays, interest in the site selection of solid waste is increasing. In this context, some of the studies on solid waste location selection are given below. Hokkanen and Salminen (1997) They presented a report on the actual implementation of the ELECTRE III decision on the selection of solid waste management system in the Oulu region of Finland. The ELECTRE III method has been useful in selecting solid waste management systems where the results of the various alternatives are somewhat uncertain. Kapepula and et.al. (2007) They worked on solid waste management in Dakar. It is aimed to find the worst and best areas for better waste management in terms of waste production, their collection and processing, and PROMETHEE and Argos method have been used for this research. Cheng et al. (2003) used the TOPSIS method for the selection of the regular landfill area with multi-criteria decision analysis and incomplete mixed integer linear programming methods.

Morrisey and Browne (2004) review the model types used in the municipal waste management field and highlight some important shortcomings of these models. Among the shortcomings of existing waste management models is the improvement of the assessment steps rather than the decision-making process itself. Most of the municipal waste models described in the literature are decision support models and for the purposes of this study, three categories are categorized: those based on cost-benefit analysis, based on life-cycle assessment, and based on multi-criteria decision-making. Chenayah et al. (2005), the amount of solid waste per capita in Malaysia ranges from 0.45 kg / day to 2 kg / day depending on the economic situation of the region. They used the PROMETHEE method to evaluate various recycling strategies and increase their activities. Ohman and et al. (2007) the paper discusses the implementation of an analytical hierarchy process (AHP) of another decision-making tool, which addresses priority ranking for engineering design and operating objectives in a number of emerging and developed countries. In the study, AHP is used for regular landfill operations from the community to the landfill area and specific to the collapse levels. It is also used to list and prioritize economic, environmental, health and safety, legal and public perception goals.

Çay et al. (2007) used constraints such as proximity to the city center, wells and irrigation channels, transportation routes and railways, distance from protected areas and population, land use, land value and land slope to determine the most suitable areas in Çumra district. A final map for the working area is produced and the most suitable areas for the selection of the warehouse area are shown. Khan and the other. (2008) the study presented an assessment method for selecting and prioritizing appropriate municipal solid waste disposal methods to decision makers in a local non-governmental organization. Using the analytical network process, five main criteria, thirteen sub-criteria and three alternatives were studied.

Ekmekçioğlu et al. (2010) has proposed fuzzy TOPSIS methodology for the selection of the appropriate disposal method and solid waste site. The method is superior to other methods because it has the ability to represent uncertain qualitative data and to present the possible results of membership at different degrees. It is considered as a fuel alternative derived from regular landfill, composting, incineration and waste. The weights of the selection criteria are determined by the Analytical Hierarchy Process fuzzy pair comparison matrices. It has been determined that the fuel derived from waste is the best alternative for the province of Istanbul. In the research conducted by Cora (2014), Alternative solid waste landfill areas were determined by using geographic information systems according to the criteria applied in the selection of solid waste landfill areas in two study areas selected on the Anatolian side of Istanbul. Şalvarlı (2015) has implemented an application using the analytical hierarchy method for the selection of a suitable packaging waste recycling center in İzmir. The Expert choice software that supports AHP provides statistical analysis data and the results are given in detail.

Vucijak et al. (2016), in order to find the best scenario in the solid waste management of Bosnia and Herzegovina, it has made very specific decision making applications. Among the six alternatives, technological, economic, social and environmental targets have been taken in order to select the best municipal solid waste management scenario and multi-criteria decision making methods have been evaluated. In the literature review, no other study has been found on the determination of the importance of solid waste site selection criteria and the most appropriate solid waste site selection.

This fact is considered as a factor that increases the importance of the study. In addition, there was no study using the solid waste selection criteria and SWARA-MOORA integrated approaches in selecting the most suitable solid waste site. Therefore, it is considered that this study will contribute to the literature.

3. Research Method

In the determination of the weights of the criteria for the selection of solid waste in Kars, SWARA which is the Multi Criteria Decision Making (MCDM) method was used and the criteria weights were determined by SWARA. In the next step, MOORA method was used to determine the most suitable solid waste location by using the determined weights. In this context, SWARA and MOORA method used for the evaluation of the criteria for the selection of solid waste site are explained.

3.1. SWARA Method

The SWARA method is one of the Multiple Criteria Decision-Making methods that are used to derive the uncertainties involved in the process of evaluating linguistic expressions of criteria and alternatives (Alimardani et al., 2013: 542). The main advantage of the SWARA method in decision-making problems is that it does not need any evaluation to solve decision problems and to rank the criteria and It is a benchmark to determine priorities based on the strategies or plans of the enterprises or on the policies of the countries (Kouchaksaraei et al., 2015: 115). In this respect, the basic steps of the SWARA method are as follows (Ruzgys et al.,2014 : 107; Stanujkic et al., 2015:182):

Step 1: Sort the criteria:

The criteria are listed in simple terms in descending order of importance in line with expert opinion. If more than one expert evaluates the criterion, each expert's individual benchmarking criterion is sorted in descending order and a general ranking is made by taking the geometric mean of the criteria**.**

Step 2: Determine the relative importance of each criterion:

For this, the j.criterion$(j+1)$ is compared with the criterion$(j+1)$., and it is determined how important the criterion$j$.is from the criterion j.. For this comparison, the variable proposed by Keršuliene vd. (2010) is denoted by $s_j$and is called the "comparative significance of the mean value".

Step 3: Determination of the coefficient:

The coefficient k_j is calculated using Equation (1).

$$k_j = \begin{cases} 1 & j = 1 \\ s_j + 1 & j > 1 \end{cases} \quad (1)$$

Step 4: Calculation of variable q_j:

The variable is calculated using Equation (2).

$$q_j = \begin{cases} 1 & j = 1 \\ \frac{q_{j-1}}{k_j} & j > 1 \end{cases} \quad (2)$$

Step 5: Determine Criteria Priority Rating:

The relative weights of the evaluation criteria are calculated using Equation (3).

Indicates the relative weight of the criterion.

$$w_j = \frac{q_j}{\sum_{k=1}^{n} q_k} \quad (3)$$

3.2. MOORA Method

This method, developed by Brauers and Zavadskas, is one of the most commonly used methods to develop different applications to support decision making problems used in different areas in recent years. In MOORA, the rate method and the reference point approach are used to solve many important decision making problems.The steps of the MOORA method are given below. (Brauers and Zavadskas, 2006:447; Brauers and Zavadskas, 2009: 356- 357, Metin et al., 2017, 382-383).

Step 1: Creation of a Decision Matrix:

In the decision matrix, the decision points that are wanted to be ranked in the line of the decision matrix and the criteria that are used in decision making are shown in the column section.

$$X=\begin{bmatrix} X_{11} & X_{12} & \cdots & X_{1n} \\ X_{21} & X_{22} & \cdots & X_{2n} \\ \vdots & \vdots & \ldots & \vdots \\ X_{n1} & X_{n2} & \cdots & X_{nn} \end{bmatrix} \quad (4)$$

Step 2: Normalization of Decision Matrix:

The squares of the values in the decision matrix are added and the square root of the added squares are taken. Then each value in the decision matrix is divided by the square root of the sum of the squares of the relevant column and the normalization process is completed.

$$xij = \frac{\mathrm{Xij}}{\sqrt{Xij2}} \quad (5)$$

Step 3: Determination of Maximum and Minimum Criteria and Calculation of MOORA Score:

In this step, the criteria included in the normalized decision matrix are determined according to whether they are the maximum or minimum for the benefit of the enterprise. The value of the minimum criteria added is subtracted from the value of the maximum criteria added. . j = 1,2,…,g criteria to be maximized and ve j = g + 1, g + 2,…n criteria to be minimized The MOORA score is calculated as follows:

$$y_j^* = \sum_{i=1}^{i=k} Xij - \sum_{i=k+1}^{i=n} Xij \quad (6)$$

4. Implementation

In this study, a multi-criteria decision model has been formed to evaluate the criteria to be used in the process of selecting solid waste landfill in Kars province. In the study, the criteria of solid waste landfill location were determined by using literature review with expert opinions. The criteria were weighted because the determined criteria were not equal importance. In this context, solid waste landfill criteria are weighted by SWARA method. The following table was formed by using expert opinions, literature review, academicians, municipalities and Special Provincial Administration authorities.

Table 1. Decision Criteria

Main Criteria	Reference
Underground Water Conservation Areas (C1)	Çay et al. (2007)
River System (C2)	Çay et al. (2007)
Wildlife Conservation Areas (C3)	Çay et al. (2007)
Soil and Geological Structure(C4)	Çay et al. (2007), Cora (2014)
Distance to Urban Areas (C5)	Çay et al. (2007) (2007), Cora (2014)
Historic and Important Cultural Areas (C6)	Çay et al. (2007)
Population Density (C7)	Çay et al. (2007) , Şalvarlı (2015)
Road Network (C8)	Cora (2014), Şalvarlı (2015), Khan et al. (2008)
Land Costs (C9)	Morrisey snd Browne (2004), Khan et al. (2008)
Slope (C10)	Çay et al. (2007) Cora (2014)

4.1. Weighting Criteria

In this phase, which utilizes the SWARA method, a general ranking account has been made to evaluate the criteria. A total of 7 questionnaires were presented to academicians (2), municipal authorities (3), and Special Provincial Administration officials (2), which are participants of the subject. The tables containing the interviews are presented in the Annexes. Thus, weights were determined with SWARA for the weighting of the criteria and the criterial weights given in Table 2 were obtained.

Table 2. Criterion Weights Table

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}
Weight	0,079	0,059	0,156	0,117	0,105	0,091	0,130	0,066	0,143	0,054

The most important criteria of the landfill site selection criteria for Table 2 were found to be "Natural Life Protected Areas", "Land Costs", "Population Density", "Soil and Geological Structure" and "Distance to Urban Areas".

4.2. Ranking Alternatives

MOORA method was used in this section to rank the alternatives. By using the weight of the criteria obtained by the SWARA method, MOORA method is used to select the most suitable solid waste site and the alternatives are listed. A questionnaire was applied to evaluate each alternative within the framework of previously determined decision criteria. In this context, decision matrices were created and then the decision matrices were normalized. The tables related to the opinions are presented in the Appendix. In this context, the rank obtained by MOORA method is given in Table 3. below.

Table 3. Ranking of options according to Moora's importance coefficient

	A_1	A_2	A_3	A_4
Y_i	0,170	0,185	0,169	0,243
Ranking	3	2	4	1

According to Table 3, where MOORA method is used, in the order of the most suitable solid waste location selection, A4 alternative in Kars province has been the most suitable solid waste location. On the other hand, the most appropriate choice of solid waste location in Kars province is A4> A2> A1> A3.

5. Conclusions and Recommendations

Within the scope of sustainable development approach all over the world; waste management strategies are adopted that aim to transform wastes into economic inputs rather than threats in terms of environment and human health. Integrated solid waste management is a process that begins with waste reduction, reuse, recycling and recycling practices and ends with the collection and disposal of waste. Our country is faced with the problem of waste along with the rapid economic growth as well as the increasing urbanization, population growth and welfare level. The development of a holistic approach to the solution of the waste problem has great importance for the sustainable development of our country. As a result of this study, the most important criteria for selection of solid waste sites are "Natural Life Protected Areas", "Land Costs", "Population Density", "Soil and Geological Structure" and " Distance to Urban Areas ". On the other hand, the least important criteria were identified as “slope”, “River system”, ”road network”, “underground water conservation areas” and “historic and important cultural areas” respectively. In this study, using the weights determined by the SWARA method, the order of the alternatives was selected by the MOORA method to select the most suitable solid waste site. According to the MOORA significance coefficient, the most suitable solid waste site choice was A4 alternative. This work has been discussed with experts who are considered to be parties to this subject, but this number has not been increased due to time constraints. On the other hand, the problem addressed in this study can be applied to other areas. In addition, the study can be developed in the future with the addition of fuzzy logic with other MCDM and other parametric or nonparametric methods, and the results can be compared and discussed.

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APPENDIX

APPENDIX:1 Calculation of General Ranking

Criterion Name	CAV_1	CAV_2	CAV_3	CAV_4	CAV_5	CAV_6	CAV_7	Geo. Mean
C_1	8	6	8	7	7	8	7	7,2508
C_2	10	10	6	9	9	9	10	8,8858
C_3	1	1	2	1	1	3	1	1,2917
C_4	4	5	5	4	4	4	5	4,4014
C_5	5	4	4	6	5	6	4	4,7869
C_6	6	8	7	5	6	5	6	6,0665
C_7	2	2	3	2	2	2	3	2,2456
C_8	7	7	9	8	8	7	8	7,6832
C_9	3	3	1	3	3	1	2	2,0684
C_{10}	9	9	10	10	10	10	9	9,5584

APPENDIX:2 Calculation of Parameters for Decision Maker 1

Criterion Name	Order of Importance	S_j	C_j	q_j	W_j
C_1	7	-	1	1	0,149
C_2	8	0,05	1,050	0,952	0,142
C_3	1	0,10	1,10	0,866	0,129
C_4	4	0,10	1,10	0,787	0,117
C_5	5	0,10	1,10	0,716	0,107
C_6	6	0,15	1,15	0,623	0,093

C_7	3	0,15	1,15	0,542	0,081
C_8	8	0,10	1,10	0,471	0,070
C_9	2	0,20	1,20	0,393	0,059
C_{10}	10	0,10	1,10	0,357	0,053

APPENDIX:3 Calculation of Parameters for Decision Maker 2

Criterion Name	Order of Importance	S_j	C_j	q_j	W_j
C_1	7	-	1	1	0,138
C_2	8	0,05	1,05	0,952	0,132
C_3	1	0,05	1,05	0,907	0,126
C_4	4	0,10	1,10	0,825	0,114
C_5	5	0,15	1,15	0,717	0,099
C_6	6	0,10	1,10	0,598	0,083
C_7	3	0,10	1,10	0,544	0,075
C_8	8	0,15	1,15	0,473	0,065
C_9	2	0,10	1,10	0,430	0,060
C_{10}	10	0,05	1,05	0,410	0,056

APPENDIX:4 Calculation of Parameters for Decision Maker 3

Criterion Name	rder of Importance	S_j	C_j	q_j	W_j
C_1		-	1	1	0,144
C_2		0,10	1,10	0,909	0,131
C_3		0,10	1,10	0,866	0,125
C_4		0,05	1,05	0,824	0,118
C_5		0,05	1,05	0,786	0,113
C_6		0,15	1,15	0,683	0,098
C_7		0,20	1,20	0,569	0,082
C_8		0,20	1,20	0,474	0,068
C_9		0,10	1,10	0,431	0,062
C_{10}	0	0,05	1,05	0,411	0,059

APPENDIX:5 Calculation of Parameters for Decision Maker 4

Criterion Name	Order of Importance	S_j	C_j	q_j	W_j
C_1		-	1	1	0,151
C_2		0,15	1,15	0,870	0,131
C_3		0,10	1,10	0,791	0,119

C_4	4	0,10	1,10	0,719	0,108
C_5	5	0,05	1,05	0,684	0,103
C_6	6	0,05	1,05	0,652	0,098
C_7	3	0,15	1,15	0,567	0,086
C_8	8	0,15	1,15	0,493	0,074
C_9	2	0,10	1,10	0,448	0,068
C_{10}	10	0,10	1,10	0,407	0,062

APPENDIX :6 Calculation of Parameters for Decision Maker 5

Criterion Name	Order of Importance	S_j	j	q_j	W_j
C_1	7	-		1	0,162
C_2	8	0,10	,10	0,909	0,147
C_3	1	0,05	,05	0,866	0,140
C_4	4	0,15	,15	0,753	0,122
C_5	5	0,20	,20	0,627	0,101
C_6	6	0,20	,20	0,523	0,086
C_7	3	0,20	,20	0,436	0,070
C_8	8	0,10	,10	0,396	0,064
C_9	2	0,10	,10	0,360	0,057
C_{10}	10	0,15	,15	0,313	0,051

APPENDIX:7 Calculation of Parameters for Decision Maker 6

Criterion Name	Order of Importance	S_j	C_j	q_j	W_j
C_1	7	-	1	1	0,151
C_2	8	0,05	1,05	0,952	0,143
C_3	1	0,05	1,05	0,907	0,137
C_4	4	0,15	1,15	0,788	0,119
C_5	5	0,15	1,15	0,685	0,103
C_6	6	0,10	1,10	0,624	0,094
C_7	3	0,10	1,10	0,567	0,085
C_8	8	0,15	1,15	0,454	0,067
C_9	2	0,25	1,25	0,363	0,055
C_{10}	10	0,25	1,25	0,302	0,046

APPENDIX :8 Calculation of Parameters for Decision Maker 7

Criterion Name	Order of Importance	S_j	C_j	q_j	W_j
C_1	7	-	1	1	0,185
C_2	8	0,15	1,15	0,870	0,161
C_3	1	0,15	1,15	0,725	0,134

C_4	4	0,20	1,20	0,604	0,112
C_5	5	0,15	1,15	0,525	0,097
C_6	6	0,10	1,10	0,477	0,088
C_7	3	0,25	1,25	0,382	0,072
C_8	8	0,25	1,25	0,306	0,057
C_9	2	0,15	1,15	0,266	0,049
C_{10}	10	0,10	1,10	0,242	0,045

APPENDIX:9 Decision Matrix According to MOORA Significance Factor

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}
Yön.	Max.	Max.	Max.	Max.	Min.	Max.	Max.	Max.	Min.	Min.
A_1	5	3	4	6	7	3	2	4	5	7
A_2	8	4	2	3	9	5	4	6	4	5
A_3	3	4	3	5	7	6	4	5	7	6
A_4	7	5	4	3	6	5	7	7	8	5