

# A MCDM approach to the facility location selection problem of sustainable solid waste management

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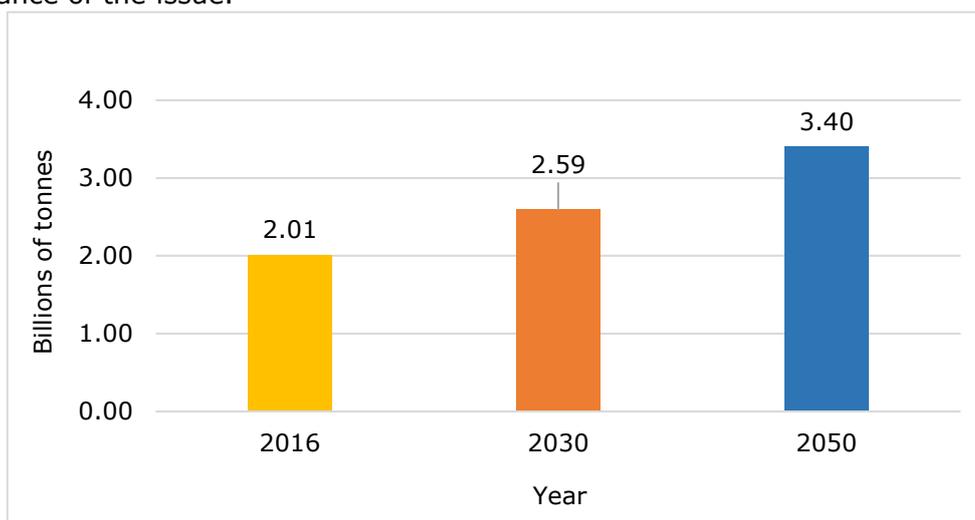
**Keywords:** sustainability; solid waste; multi criteria decision making; facility location; TOPSIS; EDAS

**Abstract:** Managing the solid wastes improperly or without sustainability concept will inevitably result in low-grade environmental hygiene and public health, comprising explosion of infectious diseases like malaria, cholera, typhoid/paratyphoid fever, etc. However, managing solid wastes in a sustainable way can reduce both amount of solid wastes and solid waste separation practices. Within this scope, this study concentrates on the establishment of a new sustainable solid waste disposal facility in Türkiye's Mediterranean Region via two effective Multi Criteria Decision Making (MCDM) methods. For this aim, nine criteria; including cost, closeness to residential areas, land slope, environmental risks (e.g., earthquake risk and closeness to water), and public acceptance are utilized through expert evaluations and relevant literature. The most appropriate location is analysed through Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) and Evaluation based on Distance from Average Solution (EDAS). Both methods consistently determined Yeşilyurt Neighborhood in Seyhan District ( $A_1$ ) as the most suitable location for the new solid waste disposal facility. The sensitivity analysis confirmed the robustness of the findings, demonstrating that  $A_1$  remained the top-ranked alternative under various criteria weights. It is expected that the results obtained will guide the decision makers in this area.

## 1. Introduction

The Sustainable Development Goals are United Nations' universal invitation to act for a sustainable world to extinguish poorness, preserve our planet, and ensure that all people live in peace and prosperity (United Nations Development Programme). In the Sustainable Development Goals, 17 goals and 169 sub-goals have been determined to achieve these goals, and indicators have been selected to monitor the level of access to goals at a global scale. In addition, these goals provide clear guidance and objectives for all countries to follow, based on their precedencies and the environmental problems of the universe. Besides, it's important to point out that, with the effect of industrialization and urbanization in an increasingly globalized world, resources are being used unconsciously. As a result of this mass consumption, waste is being generated. Waste refers to materials produced in consequence of the manufacturing and consumptive actions carried out by the consumer which is no longer needed, have completed their useful life and are to be removed from the environment. Wastes are among the main causes of global environmental pollution. Various waste amounts increase day by day via an ever-growing consumption pattern and these amounts have extended to high proportions that threaten both the environment and human health based upon their volume and hazardous components.

With the light of these information, this research focuses on the sub-goal number 5 of the 12<sup>th</sup> goal "Responsible Production and Consumption" within 17 Sustainable Development Goals. This goal concentrates on significantly decreasing the production of solid waste by 2030 through prevention, reduction, recycling and reuse. It also includes ensuring sustainable production and consumption patterns. In line with this, Figure 1 below demonstrates the estimated global waste generation utilizing 2016 waste data (Kaza et al., 2018). As seen in Figure 1; it is expected that approximately 3,40 billion tonnes of waste will be generated across the world by 2050 which is 0,81 billion tonnes higher than the 2030 estimation. In fact, even these large values of waste underline the importance of the issue.



**Figure 1.** Estimated Global Waste Generation (generated via Kaza et al., 2018)

As for solid waste; it is described as "solid materials and treatment sludge which are proposed to be thrown by the producer and must be thrown off on a regular basis with regards to the peace of the society and particularly the protection of the environment" (Solid Waste Control Regulation, 1991). The concept of solid waste generally refers wastes that are in the solid state of matter, but also includes wastes that are not as fluid and not gaseous as water or any other liquid (Tchobanoglous et al., 1993). The irregular storage of solid wastes has some dangerous consequences such as pollution of underground, drinking and utility water; life-threatening and pollution caused by landfill gas; image pollution; air pollution; the risk of carrier pest reproduction; landslide risk etc.

Solid waste management is the name given to the process carried out to reduce the waste produced, to ensure the economic recovery of the waste, to inhibit the devastation to the living things in the air, soil and water environment in the process from its production to its destruction (Bilgili, 2020). It is one of the most pressing challenges faced by municipal societies. Furthermore, in the literature, the sustainability issue is frequently encountered in the waste management context. Since the environment and development are integrated with each other in many different fields; sustainability science offers an integrated perspective that closely links human and environment systems (Jalalipour et al., 2021).

Sustainable solid waste management concept relies on the approaches which prioritize waste decrease at the source after the solid waste is generated, then using the remaining waste as energy, as an economic value, if possible. Subsequently, the environmental processes such as recycling are implemented, followed by the reduced amount of remaining waste. Numerous solid waste policy-makers are adopting sustainability implementations and the frequently utilized approaches in this area are zero-waste, circular economy and sustainable materials management (Anshassi et al., 2019; Mandpe et al., 2023). The reason is that implementing systematic sustainable solid waste management policies can inhibit the damage to environment and preserve currently inadequate natural resources. Amongst the academic literature on this topic,

many studies concentrated on various aspects about sustainable solid waste management issues: presenting approaches, plans, concepts or applications for cities/countries (Kgathi and Bolaane, 2001; Jha et al., 2011; Lü et al., 2012; Jakubiak, 2014; Permana et al., 2015; Ibrahim and Mohamed, 2016; Ikhlayel and Nguyen, 2017; Kaur and Deswal, 2019; Byers et al., 2020; Asefi et al., 2020; Nyampundu et al., 2020; Tsai et al., 2021; Jalalipour et al., 2021; Andeobu et al., 2022; Bui and Tseng, 2022; Emará, 2023; Suryawan and Lee, 2023); gaining new understandings into sustainable waste management (Wagner, 2011); proposing theoretical economic model exploring the policy alternatives which could prompt the effectiveness of secondary raw material markets (Schreck and Wagner, 2017); conducting a comparative investigation of integrated and sustainable solid waste management via data from 20 cities to gain some perceptive (Wilson et al., 2012); concentrating on specifying sustainable waste management programs' affects and evaluating their inclusive effects on stakeholders (López-Toro et al., 2016); analysing the contribution of small-scale housing businesses to sustainable solid waste management in Ghana (Agyeiwaah, 2020) and researching centralized and decentralized procedures through a sophisticated government for sustainable solid waste management in Lebanon (Massoud et al., 2019). In other aspects, Pongpimol et al. (2020) evaluated alternative sustainable solid waste management strategies on flexible packaging using a multi criteria evaluation approach. Bui et al. (2020) intended to specify the crucial obstacles for sustainable solid waste management utilizing the fuzzy Delphi method to obtain valid and credible properties with qualitative information. As for locating solid waste facilities, multi criteria decision making (MCDM) approaches have been adopted in some papers. For example, while Cheng et al. (2003) focused on land-fill site selection; Mourmouris (2006) focused on waste disposal facility location selection via Weighting Sum Method, Élimination Et Choix Traduisant la REalité II (ELECTRE II). The Analytic Network Process (ANP) is utilized by Tuzkaya et al. (2008) for locating undesirable facilities and by Aragonés-Beltrán et al. (2010) for siting municipal solid waste plants. Ekmekçiođlu et al. (2010) employed a modified fuzzy Technique for Order Preference by Similarity to Ideal Solutions (TOPSIS) to select both appropriate disposal method and municipal solid waste site. The Analytic Hierarchy Process (AHP) and Geographic Information System (GIS) are used by Şener et al. (2011) and Kumar et al. (2014) for solid waste disposal site selection, while Aydemir-Karadađ (2019) applied Goal Programming and AHP for the same purpose.

Based on this literature review, despite the studies specified above, we can observe that there is still insufficient attention to the location of solid waste facilities within the MCDM framework. Hence, this study aims to fill this gap in the literature by presenting valuable research on the location of a sustainable solid waste facility and introducing a case study in Türkiye.

In this context, our contributions compared to the literature can be summarized as stated below:

- Despite the studies mentioned above, the literature has not adequately addressed the issue of sustainable solid waste disposal facility location from an MCDM perspective. Thus, this study purposes to fill this gap and serve as a valuable resource for similar topics.
- Two common MCDM methods were employed in this study to reinforce the effectiveness of the results.
- Sensitivity analysis was performed for the employed two methods to monitor changes in the alternative rankings.
- To ensure error-free data about the criteria, various experts in this field were consulted in our study, including geological engineers, environmental engineers, municipal employees, civil engineers, and urban planners.

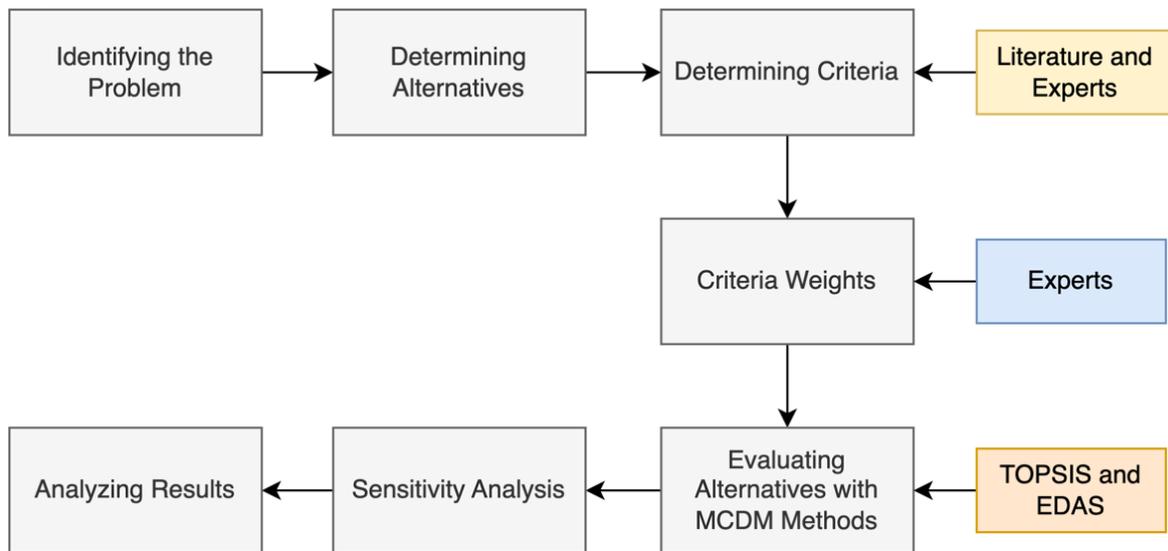
In light of these intended contributions to the literature, this study aims to determine a sustainable solid waste disposal facility location within two provinces in the Mediterranean Region of Türkiye. The selection of this region is based on its high population and the presence of organized industrial zones that are actively engaged in

high-volume trade. As outlined in the materials section, despite these factors, the number of solid waste disposal facilities in the relevant provinces remains insufficient. This study aims to find out the most suitable location for a new solid waste disposal facility to contribute to the sustainable disposal of solid waste in the addressed region.

To this end, the remainder of this study is organized as follows. Section 2 provides related information about the materials; including the study area, criteria and the MCDM methods utilized. Section 3 presents the case study, results and sensitivity analyses, along with the relevant tables and figures. Finally, the discussion and conclusions are presented in Sections 4 and 5, respectively.

## 2. Materials and Methods

The solid waste disposal facility site selection process consists of several steps, as shown in Figure 2. As illustrated in this Figure, the first step is to define the problem, as a deeper understanding of the issue naturally leads to better solutions for decision-makers. Thus, this is the most crucial stage of the selection process. In the next step, alternative locations in the studied region were determined, as explained in detail in the materials section. Then, relevant criteria were identified with the help of literature and experts. Following this, criteria weights were assigned based on the experiences and opinions of the experts. The next stage involves the evaluation of alternatives using the TOPSIS and EDAS MCDM methods. To verify the results, sensitivity analyses were performed, and the final outcomes were interpreted at the final steps of the process, respectively.



**Figure 2.** The Methodology Adopted in the Study

### 2.1. Materials

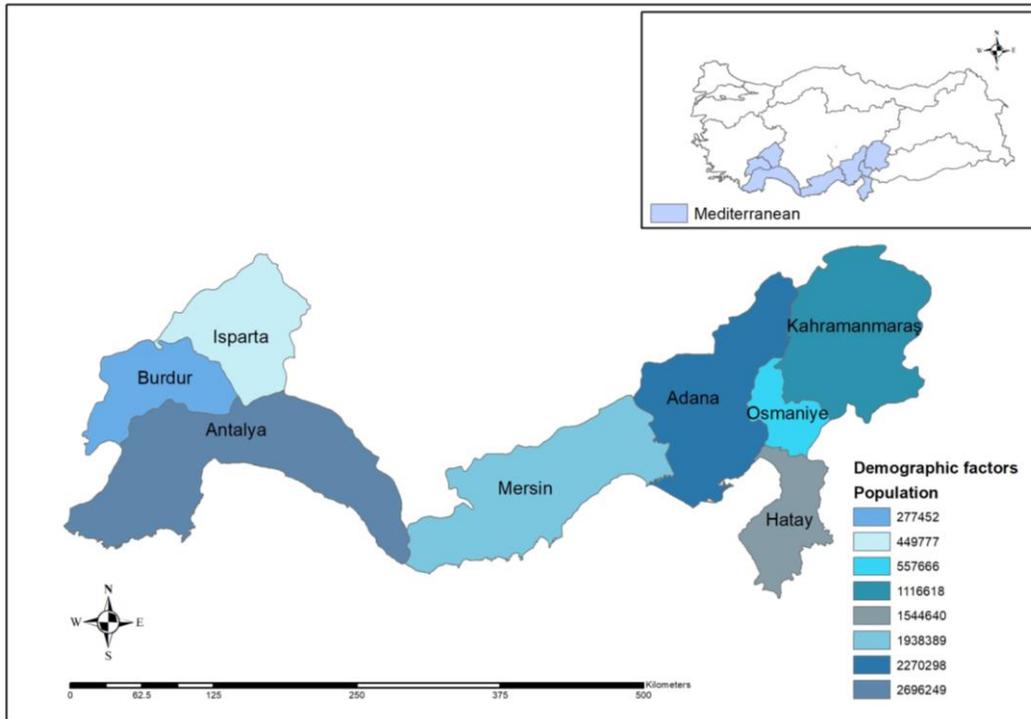
Table 1 below presents some relevant factors, including the names of provinces in Türkiye's Mediterranean geographical region, total population, number of organized industrial zones, and number of solid waste disposal facilities. Table 1 shows that there are four provinces in the Mediterranean Region with a population of over 1,500,000 people: Adana, Antalya, Hatay, and Mersin. Between these provinces, the reason for excluding Antalya from this study is that, despite having the highest population in the Mediterranean Region, it has only one organized industrial zone. Additionally, along with its two solid waste disposal facilities, it has five solid waste landfill facilities. Hatay province, on the other hand, has been excluded from the study due to its geographical limitations for development, weak infrastructure conditions, and the further deterioration of its infrastructure following the earthquake in February 2023. In light of this information, among the provinces listed in the Table 1, Adana and Mersin have been

included in the case study of this research to determine the best location for a new solid waste disposal facility.

**Table 1.** Some Relevant Factors About Mediterranean Region in Türkiye

Province	Total Population	Number of Organized Industrial Zones	Number of Solid Waste Disposal Facility
Adana	2.270,298	3	1
Antalya	2.696,249	1	2
Burdur	277,452	3	1
Hatay	1.544,640	5	1
Isparta	449,777	2	1
Kahramanmaraş	1.116,618	4	1
Mersin	1.938,389	3	3
Osmaniye	557,666	2	1

The location of the Mediterranean Region on the map of Türkiye and the provinces in this region are shown in Figure 3 below. The location of the geographical region on the map of Türkiye is provided in the upper right corner of the figure. In the main part of the Figure 3, the provinces in this region are shown and the population of these provinces is presented in the lower right corner of the figure.

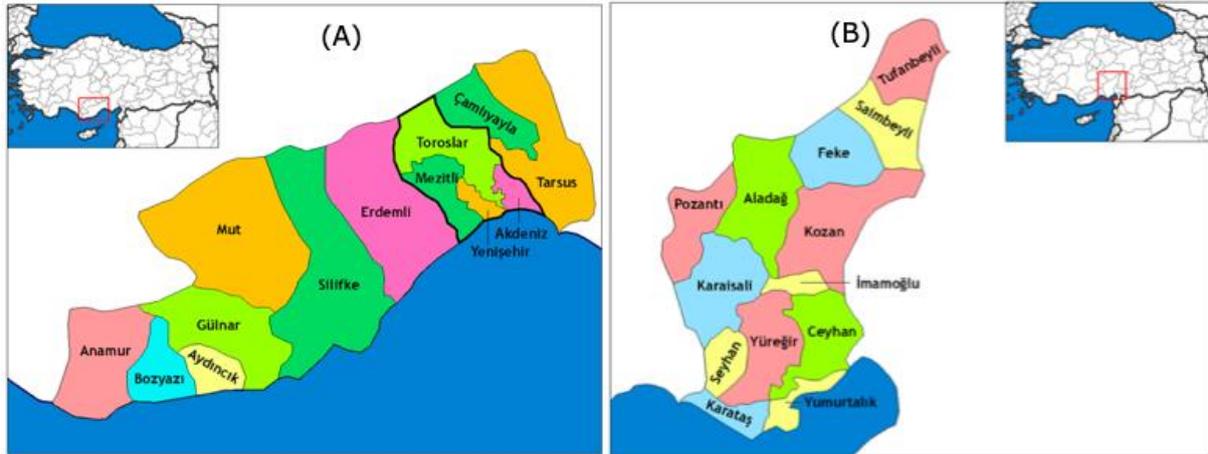


**Figure 3.** Location of the Mediterranean Region on the Map of Türkiye and Provinces in This Region

After selecting the provinces, district populations and the locations of existing solid waste disposal facilities in these provinces were examined to determine which districts in these provinces could be included into the case study. In Figure 4 below, the districts of Mersin province are shown in Figure 4(A), while the districts of Adana province are shown in Figure 4(B). The figure also indicates the locations of these provinces on the map of Türkiye. For example, the location of Mersin on the map of Türkiye is shown in the upper left corner of Figure 4(A), whereas the location of Adana on the map of Türkiye is shown in the upper right corner of Figure 4(B).

In Table 2 below, the population data of Adana and Mersin provinces are presented on a district basis. Among these data, the two districts with the highest population in Adana, Seyhan and Yüreğir, have been included in the case study (Currently, the existing

solid waste disposal facility is located in the Sarıçam district). In Mersin, there are three existing solid waste disposal facilities, located in the Akdeniz, Tarsus, and Silifke districts. Therefore, these three districts have been excluded from the study. Among the remaining districts, the ones with the highest population, Toroslar and Yenişehir, have been included in the case study.



**Figure 4.** Mersin and Adana’s Districts Representation

**Table 2.** Population Data of the Districts of Adana and Mersin Provinces

<b>Adana Province Districts</b>	<b>Total Population</b>	<b>Mersin Province Districts</b>	<b>Total Population</b>
Aladağ	16,954	Akdeniz	260,879
Ceyhan	156,610	Anamur	66,940
Çukurova	374,205	Aydıncık	11,662
Feke	17,304	Bozyazı	26,985
İmamoğlu	27,341	Çamlıyayla	8,692
Karaisalı	23,105	Erdemli	153,967
Karataş	25,245	Gülnar	33,986
Kozan	132,642	Mezitli	223,424
Pozantı	20,733	Mut	63,516
Saimbeyli	13,857	Silifke	137,047
Sarıçam	236,298	Tarsus	353,469
Seyhan	787,771	Toroslar	320 377
Tufanbeyli	17,258	Yenişehir	277 445
Yumurtalık	18,630		
Yüreğir	402,345		

In this study, rather than selecting specific locations for sustainable solid waste disposal facilities, it was considered more suitable to identify candidate neighbourhoods from the districts included in the study. Given the large number of neighbourhoods in these extensive districts, the neighbourhoods with the highest populations in the four relevant districts were selected as candidate locations for the study, with input from expert opinions. Based on this approach, in Adana; Yeşilyurt Neighbourhood (Alternative 1 - A<sub>1</sub>) in the Seyhan district and Kışla Neighbourhood (Alternative 2 - A<sub>2</sub>) in the Yüreğir district; in Mersin, Halkkent Neighbourhood (Alternative 3 - A<sub>3</sub>) in the Toroslar district, and Çiftlikköy Neighbourhood (Alternative 4 - A<sub>4</sub>) in the Yenişehir district were selected as the four alternative locations for the case study.

Based on the relevant literature and expert opinions, nine criteria were employed to identify the most suitable location for a new solid waste disposal facility. Detailed information about the experts is provided in Table 3 below.

**Table 3.** Comprehensive Information of the Experts Referred

Expert No.	Area of Expertise	Experience (Year)	Job Title	Education State
1	Geological Engineer	14	Expert Manager	Bachelor
2	Environmental Engineer	16	Manager	Master
3	Municipal Official	20	Chief	Master
4	Civil Engineer	13	Expert Engineer	Bachelor
5	City Planner	17	Manager	Bachelor

All the evaluated criteria have been measured by all the evaluators, who are experts with different perspectives, as outlined above, and the criteria are specified below (However, since the alternatives are located in the same climatic zone of Türkiye, the Mediterranean Region, the climate factor was not included in the criteria.):

Costs ( $C_1$ ): Construction, capital, operational and transportation costs play a significant role in locating a solid waste facility (Karagiannidis and Moussiopoulos, 1998; Cheng et al., 2003; Al-Jarrah and Abu-Qdais, 2006; Tuzkaya et al., 2008; Khan and Faisal, 2008; Ekmekçioğlu et al., 2010; Aydemir-Karadağ, 2019).

Site Capacity ( $C_2$ ): The location should have sufficient capacity for a minimum ten years of operations (Mourmouris, 2006; Al-Jarrah and Abu-Qdais, 2006; Tuzkaya et al., 2008; Aydemir-Karadağ, 2019).

Extensibility ( $C_3$ ): In the case of need to extend the facility due to the existent and future improvements, the location should be extensible (Karagiannidis and Moussiopoulos, 1998; Cheng et al., 2003; Tuzkaya et al., 2008).

Closeness to the Residential or Developing Regions ( $C_4$ ): The facility should be located away from the residential or developing areas (Mourmouris, 2006; Al-Jarrah and Abu-Qdais, 2006; Tuzkaya et al., 2008; Aragonés-Beltrán et al., 2010; Aydemir-Karadağ, 2019).

Closeness to the Natural Protection Areas ( $C_5$ ): Since local governments designate certain natural protection areas in their urban planning, waste facilities should be located far from these areas. Poorly designed and sited waste facilities can provide ideal environments for insects and vermin, which can disrupt natural protection areas (Al-Jarrah and Abu-Qdais, 2006; Tuzkaya et al., 2008; Aragonés-Beltrán et al., 2010; Aydemir-Karadağ, 2019).

Land Slope ( $C_6$ ): This criterion affects the location decision, as a high slope increases the risk of erosion and complicates transportation operations (Al-Jarrah and Abu-Qdais, 2006; Tuzkaya et al., 2008; Şener et al., 2011; Kumar et al., 2014).

Earthquake Risk ( $C_7$ ): Areas with a high earthquake risk should be avoided, and areas with a lower earthquake risk should be preferred (Mourmouris, 2006; Al-Jarrah and Abu-Qdais, 2006; Tuzkaya et al., 2008; Aydemir-Karadağ, 2019).

Public Acceptance ( $C_8$ ): This criterion reflects the acceptance level of the local residents regarding the site and plays an important role in the location and operation of a sustainable solid waste facility (Cheng et al., 2003; Khan and Faisal, 2008; Aydemir-Karadağ, 2019).

Closeness to Underground and Surface Water ( $C_9$ ): In the case of leachate, contamination of underground and surface water is one of the primary concerns. Therefore, the location should be far from both underground and surface waters (Cheng et al., 2003; Al-Jarrah and Abu-Qdais, 2006; Tuzkaya et al., 2008; Ekmekçioğlu et al., 2010; Aragonés-Beltrán et al., 2010; Şener et al., 2011; Kumar et al., 2014; Aydemir-Karadağ, 2019).

## 2.2. Research Methodology

MCDM methods are applied widely for the solution of real-life problems and deal with the determination of the most appropriate alternative between potential decision options according to tangible and intangible criteria or characteristics. In this decision-making process, the individual preferences of evaluators/decision makers represent indefinite values since these preferences can be expressed through lingual expressions. Hence,

facility location problems, as in this study, can be evaluated as multi criteria decision problems since they contain various subjective criteria in the assessment of alternatives and the related criteria weights can be stated through linguistic expressions (Balcik and Beamon, 2008; Athawale et al., 2012; Wu et al., 2019; Miç and Antmen, 2021). Determining the most suitable location decision incorporates a variety of alternatives, goals (minimizing cost or travel distance or maximizing efficiency, etc.) and criteria. These criteria may be conflicting with each other; while one criteria correspond to maximization direction (for example site capability), another can correspond to minimization direction (for example cost). Concentrating on these points, we adopted the current sustainable solid waste facility location case as an MCDM problem and solved it by applying various effective MCDM methods. Thus, we applied two MCDM methods to the present problem: TOPSIS and EDAS. Amongst the various MCDM techniques, applied techniques come to the forefront with their ease of implementation, comprehensive concept and effectiveness.

### 2.2.1. TOPSIS Technique

The TOPSIS method was first formulated by Hwang and Yoon (1981) and can be employed in many decision problems. The technique bases upon two basic points which are stated as Positive Ideal Solution (PIS) and Negative Ideal Solution (NIS). This technique aims to determine the alternative that is the closest to the PIS and outermost to the NIS through calculating each alternative's distance to the PIS and NIS (Albulescu and Larion, 2022). The application process of the TOPSIS technique can be found in Hwang and Yoon (1981).

### 2.2.2. EDAS Technique

As a relatively new technique, the EDAS method was formulated by Keshavarz Ghorabae et al. (2015) that has been successfully applied to the solution of many problems, with the application process outlined in their work.

### 2.2.3. Sensitivity Analyses

Sensitivity analysis in MCDM is conducted to evaluate the robustness and reliability of decision results by examining how changes in the input parameters, such as criteria weights or alternative performances, affect alternatives' final rankings. This type of analysis is crucial because MCDM models often rely on subjective evaluations (e.g. expert opinions), which can insert uncertainty or bias into the decision-making process. Sensitivity analysis aids to identify which criteria or assumptions have the most significant effect on the outcomes, accordingly provides perceptions into the stability of the selected alternative under different scenarios.

Sensitivity analysis not only expands confidence in the decision-making process but also supports identifying areas where further data collection or refinement of criteria might be necessary (Zopounidis and Doumpos, 2017). By uncovering how stable the decision results are to changes in input assumptions, sensitivity analysis improves the transparency and credibility of MCDM methods in real-world applications, especially in complex or high-stakes problems like solid waste management, environmental planning, or strategic decision-making (Goulart Coelho et al., 2017).

One common type of sensitivity analysis in MCDM is changing criteria weights. This includes systematically adjusting the criteria weights of each criteria to observe how the ranking of alternatives varies. This type of sensitivity analysis helps assess the influence of each criteria on the decision process, discovering whether the final choice stays stable regardless of the variations in the importance of individual criteria (Wieckowski and Salabun, 2023). Other types of sensitivity analysis include one-at-a-time sensitivity analysis, where one parameter is changed while others are held constant; global sensitivity analysis, which simultaneously varies multiple parameters; and Monte Carlo

simulations, which use random sampling techniques to find out the potential impact of uncertainty in input data (Saltelli et al., 2009).

As in such studies conducted by Stević et al. (2020), Peng et al. (2020), Keshavarz-Ghorabae et al. (2021), Abdel-Basset et al. (2021), and Çalik (2021), this study also carries out sensitivity analyses via changing the criteria weights. Such an approach strengthens the reliability of the decision-making process by assessing the stability of the outcomes under different scenarios. Through this method, the robustness of the results is assessed, guarantying that the selected alternatives stay valid under changing conditions.

### 3. Results

#### 3.1. Decision Matrix and Criteria Weights

Initially, a decision matrix was developed based on the experts' evaluation of the performance of each alternative with respect to each criterion. These performance values were calculated as the average of the evaluations, using a scale from 1-10, where 1 demonstrates the worst performance and 10 corresponds to the best. This matrix is presented in Table 4 and also includes the directions of the criteria. Subsequently, the scores of all alternatives were normalized, and the acquired values are presented in Table 5.

**Table 4.** Decision Matrix

	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	C <sub>7</sub>	C <sub>8</sub>	C <sub>9</sub>
	Min	Max	Max	Min	Min	Min	Min	Max	Min
A <sub>1</sub>	4	8	5	5	7	2	6	8	4
A <sub>2</sub>	8	4	6	6	6	3	5	6	7
A <sub>3</sub>	7	6	5	6	7	3	6	6	6
A <sub>4</sub>	9	9	4	5	7	4	7	5	8

**Table 5.** Normalized Values of Decision Matrix

	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>	C <sub>5</sub>	C <sub>6</sub>	C <sub>7</sub>	C <sub>8</sub>	C <sub>9</sub>
A <sub>1</sub>	0,2760	0,5700	0,4951	0,4527	0,5175	0,3244	0,4275	0,7921	0,3621
A <sub>2</sub>	0,5521	0,2850	0,5941	0,5432	0,4435	0,4867	0,3562	0,5941	0,6338
A <sub>3</sub>	0,4830	0,4275	0,4951	0,5432	0,5175	0,4867	0,4275	0,5941	0,5432
A <sub>4</sub>	0,6211	0,6412	0,3961	0,4527	0,5175	0,6489	0,5793	0,3941	0,6228

In the next step, each criterion is assigned with a weight by the decision makers to obtain criteria weights based upon a 1-9 scale that 1 corresponds the worst and 9 corresponds the best. The score of each criterion is then divided by the total score with respect to these assessments, ultimately yielding the criteria weights. These weights are shown in Table 6.

**Table 6.** Criteria Weights

Criteria	Criteria Weight
C <sub>1</sub>	0,20
C <sub>2</sub>	0,11
C <sub>3</sub>	0,15
C <sub>4</sub>	0,12
C <sub>5</sub>	0,15
C <sub>6</sub>	0,05
C <sub>7</sub>	0,05
C <sub>8</sub>	0,05
C <sub>9</sub>	0,12
<b>Total</b>	<b>1,0</b>

### 3.2. TOPSIS Method Results

By multiplying criteria weights (Table 6) with the normalized values of decision matrix (Table 5), we formed the weighted normalized decision matrix, which is presented in Table 7.

**Table 7.** Weighted Normalized Values of Decision Matrix

	$C_1$	$C_2$	$C_3$	$C_4$	$C_5$	$C_6$	$C_7$	$C_8$	$C_9$
$A_1$	0,0552	0,0627	0,0743	0,0543	0,0776	0,0162	0,0214	0,0396	0,0435
$A_2$	0,1104	0,0313	0,0891	0,0652	0,0665	0,0243	0,0178	0,0297	0,0761
$A_3$	0,0966	0,0470	0,0743	0,0652	0,0776	0,0243	0,0214	0,0297	0,0652
$A_4$	0,1242	0,0705	0,0594	0,0543	0,0776	0,0324	0,0290	0,0197	0,0747

After calculating  $A^*$  and  $A^-$  values; PIS ( $S^*$ ) and NIS ( $S^-$ ) are formulated for each alternative. Finally, each alternative's relative closeness to the PIS ( $C_i^*$ ) is calculated and all these values are given in Table 8 below. The table also contains the ranking of the alternatives.

As shown in Table 8, alternative locations' ranking is:  $A_1 > A_3 > A_2 > A_4$ . This indicates that the best location to set up a novel solid waste facility location utilizing the TOPSIS method is  $A_1$  which corresponds to Alternative 1, Yeşilyurt Neighbourhood in Seyhan District.

**Table 8.**  $S^*$ ,  $S^-$ ,  $C_i^*$  Values and Ranking of Each Alternative

	$S^*$	$S^-$	$C_i^*$	Ranking
$A_1$	0,0204	0,0887	0,8127	1
$A_2$	0,0770	0,0385	0,3336	3
$A_3$	0,0581	0,0396	0,4054	2
$A_4$	0,0868	0,0407	0,3192	4

### 3.3. EDAS Method Results

The EDAS technique decision matrix utilizes the identical procedure with TOPSIS method's decision matrix. After calculating the average solution according to each criterion, PDA and NDA matrixes are obtained, as demonstrated in Table 9 and Table 10, respectively.

**Table 9.** PDA Values of Decision Matrix

	$C_1$	$C_2$	$C_3$	$C_4$	$C_5$	$C_6$	$C_7$	$C_8$	$C_9$
$A_1$	0,4286	0,1852	0,0000	0,0909	0,0000	0,3333	0	0,2800	0,3600
$A_2$	0	0	0,2000	0	0,1111	0	0,1667	0	0
$A_3$	0	0	0	0	0	0	0	0	0,0400
$A_4$	0	0,3333	0	0,0909	0	0	0	0	0

**Table 10.** NDA Values of Decision Matrix

	$C_1$	$C_2$	$C_3$	$C_4$	$C_5$	$C_6$	$C_7$	$C_8$	$C_9$
$A_1$	0	0	0	0	0,0370	0	0	0	0
$A_2$	0,1429	0,4074	0	0,0909	0	0	0	0,0400	0,1200
$A_3$	0	0,1111	0	0,0909	0,0370	0	0	0,0400	0
$A_4$	0,2857	0	0	0	0,0370	0,3333	0,1667	0,2000	0,2800

In the final step of the EDAS technique;  $SP_i$ ,  $SN_i$ ,  $NSP_i$ ,  $NSN_i$  and  $AS_i$  values of the alternatives are formulated. The alternatives are ranked according to their  $AS_i$  values and all these results are demonstrated in Table 11 below.

**Table 11.** Final Results and Alternatives' Ranking

	$SP_i$	$SN_i$	$NSP_i$	$NSN_i$	$AS_i$	Ranking
$A_1$	0,1956	0,0375	1,0000	0,9609	0,9805	1
$A_2$	0,0550	0,6350	0,2812	0,3385	0,3099	3
$A_3$	0,0048	0,2825	0,0245	0,7057	0,3651	2
$A_4$	0,0523	0,9600	0,2675	0,0000	0,1337	4

For the EDAS technique, the ranking of the alternatives is:  $A_1 > A_3 > A_2 > A_4$ . Thus,  $A_1$  (Alternative 1), Yeşilyurt Neighbourhood in Seyhan District is identified as the best location to set up the novel solid waste facility.

### 3.4. Comparison of the Results

Through comparing the two methods employed in this paper (TOPSIS and EDAS); we obtained Table 12 in the following, which demonstrates the alternatives' rankings of related methods.

**Table 12.** Comparison of TOPSIS and EDAS Rankings

	TOPSIS	EDAS
$A_1$	1	1
$A_2$	3	3
$A_3$	2	2
$A_4$	4	4

From Table 12, it can be observed that both TOPSIS and EDAS resulted in the same rankings for the alternatives, confirming the consistency and reliability of the evaluation across both methods.

### 3.5. Results of Performed Sensitivity Analyses

In this section, we carried out sensitivity analyses for both the TOPSIS and EDAS methods in order to observe each alternative's behaviour regarding each criterion. Thus, with the aim of validating our results, we created 10 different scenarios where the criteria weights were adjusted.

Figure 5 illustrates the sensitivity analysis results for the TOPSIS technique, and Figure 6 shows the results for the EDAS technique. In these figures, rankings of the alternative locations are demonstrated for all 10 scenarios.

In both Figures 5 and 6; the colours blue, red, green and purple stand for the Yeşilyurt Neighbourhood (Alternative 1 -  $A_1$ ), Kışla Neighbourhood (Alternative 2 -  $A_2$ ), Halkkent Neighbourhood (Alternative 3 -  $A_3$ ), and Çiftlikköy Neighbourhood (Alternative 4 -  $A_4$ ), respectively.

From Figure 5 and 6, it can be observed that in all sensitivity analyses  $A_1$  outperforms to other three alternatives across all scenarios and employed MCDM techniques. In TOPSIS technique sensitivity analyses,  $A_1$  has its highest value in Scenario 9 in which  $C_4$  (closeness to the residential or developing areas) has the highest criteria weight in this scenario. In the EDAS technique sensitivity analyses,  $A_1$  achieves its highest value in Scenario 7 which in this scenario  $C_1$  (costs) has the highest criteria weight. The lowest value in TOPSIS technique sensitivity analyses is observed in Scenario 8 where the value of  $A_4$  is 0,1452 by the highest criteria value of  $C_9$  (closeness to underground and surface water). A similar situation is obtained for EDAS technique sensitivity analyses, as well. In this technique, lowest value is noticed at Scenario 8 in which the value of  $A_4$  is 0,0675 with the biggest criteria value of  $C_9$ .

Throughout the performed sensitivity analysis, we can conclude that despite variations in the rankings when criteria weights are changed,  $A_1$  (Yeşilyurt Neighbourhood) consistently ranked as the most suitable location for the new solid waste

disposal facility. This points out that  $A_1$  is less sensitive to changes in the criteria weights compared to the other alternatives. Also, these results make  $A_1$  a strong candidate for further consideration.

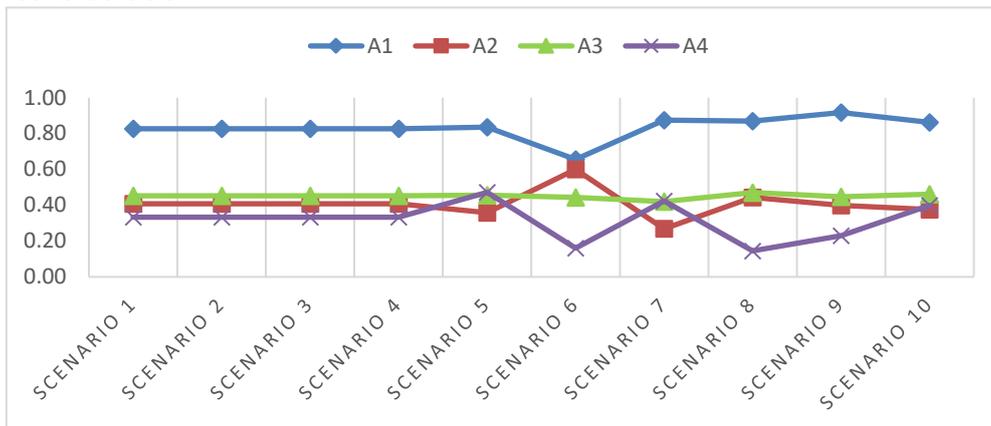


Figure 5. Sensitivity Analyses for TOPSIS Technique

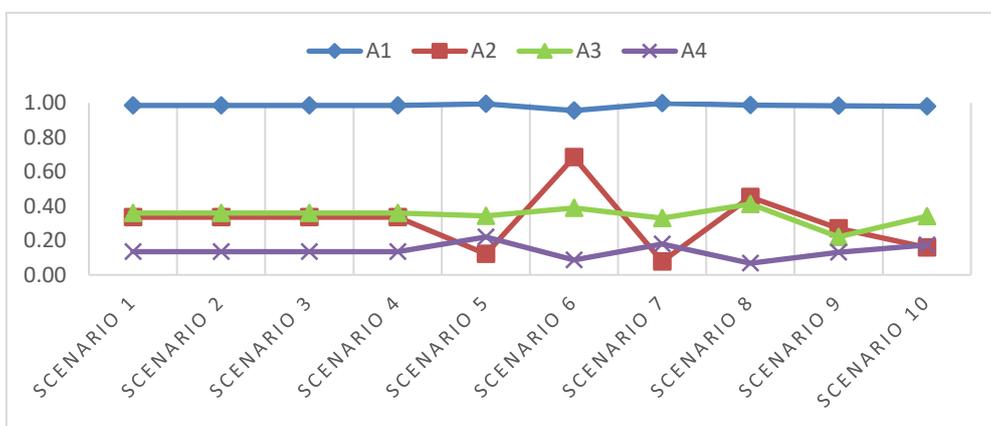


Figure 6. Sensitivity Analyses for EDAS Technique

#### 4. Discussion

This study intends to contribute to sustainable solid waste management field via specifying the most suitable location for a new solid waste disposal facility in Türkiye’s Mediterranean Region. Focusing on Adana and Mersin provinces, it concentrates on the 5<sup>th</sup> sub-goal of Sustainable Development Goal (SDG) 12, Responsible Consumption and Production. To determine the most suitable location, two widely recognized MCDM methods—TOPSIS and EDAS—are applied to a set of nine criteria derived from expert opinions and the relevant literature. Both methods identified Yeşilyurt Neighbourhood in Seyhan District ( $A_1$ ) as the most suitable location, reinforcing the robustness of this location as a potential candidate for the new facility. This finding emphasizes the consistency between the two methods, which remained stable across sensitivity analysis scenarios. In addition to the consistency and stability of the methods, the selection of Yeşilyurt Neighbourhood is notable in terms of this alternative’s stability across both methods and under a variety of sensitivity analysis scenarios. This stability means that the location is less sensitive to changes in criteria weights compared to the other alternatives. The robustness of the decision-making process makes Yeşilyurt a strong candidate for further investigation and potential development. Moreover, the location’s ranking reveals the importance of factors such as costs, land slope, and closeness to residential or developing areas, which are consistent with findings from previous studies (Cheng et al., 2003; Aydemir-Karadağ, 2019).

The results of this study are coherent with the previous research in solid waste disposal facility location field, where criteria such as cost, public acceptance, and

environmental impacts have been widely identified as critical factors in the selection process (Karagiannidis and Moussiopoulos, 1998; Mourmouris, 2006; Aydemir-Karadağ, 2019). For example, Mourmouris (2006) highlighted the importance of minimizing costs and avoiding residential areas, both of which were included in the present study. Additionally, the use of MCDM techniques for handling complex decision-making problems has been widely supported (Tuzkaya et al., 2008; Ekmekçioğlu et al., 2010), and this study reinforces their value in environmental decision-making frameworks.

This study contributes to sustainability concept by incorporating environmental (e.g., earthquake risk, closeness to underground water resources), socio-economic (e.g., public acceptance, costs) and geographical factors (e.g., land slope, closeness to residential areas) into the decision-making process. This approach is connected with the goals of SDG 12, which aims to minimize environmental harm while maximizing economic and social benefits. By addressing all of these factors, this approach offers a framework for sustainable decision making in waste management policy development.

The findings have important practical applications for waste management policies, particularly in Türkiye and similar regions around the world. By identifying a suitable location for a new solid waste facility, this study provides valuable insights for local governments, helping municipalities in improving their waste management infrastructure.

However, the study does have limitations. One key issue is data-related limitations: relying on expert opinions inserts subjectivity element, which might affect the final rankings. Although a diverse group of experts was consulted for this study, the potential for inherent biases still exists. Methodological limitations also arise from the sensitivity of both TOPSIS and EDAS methods to the quality of the input data and the assignment of criteria weights. While sensitivity analyses were conducted, the study's conclusions may still be sensitive to the specific choice of criteria weights. To mitigate these limitations in future studies, a larger and more diverse group of experts or incorporating public opinion surveys could help reduce subjectivity and enhance the robustness of the findings. Additionally, expanding the study to include more regions and a broader range of alternative sites would improve the generalizability of the results.

It should also be kept in mind that when such decisions are implemented in the real world, practical problems that are not addressed in this research will arise. These problems involve land acquisition, regulatory constraints, community resistance and unforeseen environmental impacts that can greatly affect the vitality of the suggested locations. Therefore, the findings should be examined within a broader decision-making framework that includes technical feasibility studies, legal reviews and consultations with local stakeholders. Although this study provides a solid theoretical foundation, successful practical implementations will need further engagement with government organizations and community members to handle possible complexities and ensure that all relevant factors are adequately considered.

## 5. Conclusions

This study addresses the pressing need for optimal location selection of solid waste disposal facilities in Türkiye's Mediterranean Region, employing two widely recognized MCDM methods—TOPSIS and EDAS. By considering both environmental and socio-economic factors, the study presents a comprehensive framework for choosing a sustainable facility location, with Yeşilyurt Neighbourhood identified as the most suitable location. The main findings of the study can be summarized as follows:

- Yeşilyurt Neighbourhood in Seyhan District was ranked as the most suitable location for the new solid waste disposal facility based on both TOPSIS and EDAS methods.
- Key factors influencing this ranking include cost, closeness to residential areas, land slope, and environmental risks (e.g., earthquake risk and closeness to water resources), all of which support the framework of SDG 12 by encouraging responsible resource management.

- Sensitivity analysis showed that Yeşilyurt Neighbourhood remained consistently as the best alternative across various scenarios.
- The results demonstrated the robustness of the MCDM approaches, highlighting the reliability of the TOPSIS and EDAS methods for solid waste facility location.
- Both methods provided consistent results, offering confidence in the identified location's suitability.

The findings provide valuable insights for waste management authorities and municipal decision-makers in Türkiye. This study's methodology offers a replicable framework for sustainable waste management facility planning that could be applied to other regions facing similar challenges. The study also highlights the importance of including public factors in the decision-making process, particularly in terms of public acceptance and involvement. Future research could examine incorporating public engagement to better refine the decision criteria and using more advanced methods like fuzzy logic, machine learning, or neural networks to strengthen the decision-making process.

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