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Factory Location Selection Using AHP, TOPSIS and ELECTRE Methods: A Case Study

Ozan Ateş[a*], İrem Saydam[b], Selin Çağlar[b], Yunus Emre Öztürk[b]

[a]*Istanbul Gedik University, Istanbul, Türkiye, ozan.ates@outlook.com.tr (*Corresponding Author)*
[b]*Istanbul Gedik University, Industrial Engineering Department, Istanbul, Türkiye*

Abstract

This study employs MCDM techniques—specifically AHP, TOPSIS, and ELECTRE—to identify the optimal location for a facility based on a set of predefined criteria: Proximity to Raw Materials, Proximity to Market, Workforce Potential, Technical Capabilities, Fixed Costs, and Public Supports. Within the methodological framework, the AHP approach was utilized to accurately assign weights to the evaluation criteria, whereas TOPSIS was applied to rank the alternatives based on their proximity to the ideal solution, and ELECTRE was employed to analyze the dominance relationships among the options. The implementation phase involved a comprehensive analysis of factors such as raw material access, cost structures, and labor availability using these methods, revealing that all three approaches yielded consistent and corroborative results. The case study concluded that Izmir, which received the highest performance score according to all three MCDM methods based on the defined criteria, stands out as the most strategically suitable city for olive oil factory locations.

Keywords: MCDM; AHP; ELECTRE; TOPSIS; Decision analysis.

1. INTRODUCTION

One of the most fundamental strategic decisions determining the competitiveness and profitability of businesses is location selection. This decision, which usually requires a long-term investment and has a very costly return, is vital, especially in sectors sensitive to raw materials and logistics, such as olive oil production. Choosing the wrong location can reduce operational efficiency and increase costs for businesses. Therefore, instead of intuitive approaches, it has become a necessity to use scientific and mathematical decision-making methods that analyze multiple criteria when determining the location of a facility.

The main issue addressed in this study is the location selection problem in the olive oil industry. The location of the factory is a critical variable in the process from raw material processing to market presentation. This study aims to solve the location selection problem through mathematical modeling, moving away from subjective (personal) judgments, and to identify the most suitable location. Factory location selection is, by its nature, a complex problem involving many criteria (cost, transportation, raw materials, etc.). This study aims to eliminate the potentially subjective choices of decision-makers and to reach a conclusion from a completely objective perspective. Using multi-criteria decision-making (MCDM) techniques, the developed model aims to determine the optimal location with scientific data and to present an exemplary roadmap for the sector.

Olive has taken its place in human history not only as an agricultural product but also as a cultural and mythological value. This fruit, frequently referenced in sacred texts and ancient narratives, has been a powerful symbol of prosperity, victory, and social harmony in the Anatolian civilizations of Türkiye. In addition to its indispensable place in the food sector, olive derivatives have also been used for healing purposes in traditional folk medicine. It is known that olive oil and olive pits are used especially for dermatological problems, digestive system disorders, and respiratory complaints. Furthermore, its use as fuel in lamps to meet lighting needs and its use in soap making prove that olive oil is a versatile raw material [1].

Examining history, it is believed that the wild olive, which is thought to be the ancestor of the olive, originated in Anatolia. The fact that wild olive forests are still found in Anatolia today supports this idea. However, it has been stated that the sativa subspecies of the Olea europea genus has a long historical process of approximately 6000 years. The olive processing facility, which is estimated to be from the 6th century, discovered as a result of excavation works in Urla, İzmir, is one of the best proofs of this situation [2]. The fact that it is found in more than one area, from Antalya to Bursa, supports the idea that Anatolia is the

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homeland of the olive fruit [3].

The case study presented in this study is ranking. Within the scope of the case study, 4 different alternatives representing the locations of the olive oil factory and 6 different criteria to be evaluated for these alternatives were determined. As a result of the study, the alternatives were ranked according to the 3 MCDM methods mentioned, and the alternative that had the priority in all methods was chosen to be implemented. According to Arısoy, the MCDM methods used in ranking problems are shown in Figure 1 [4].

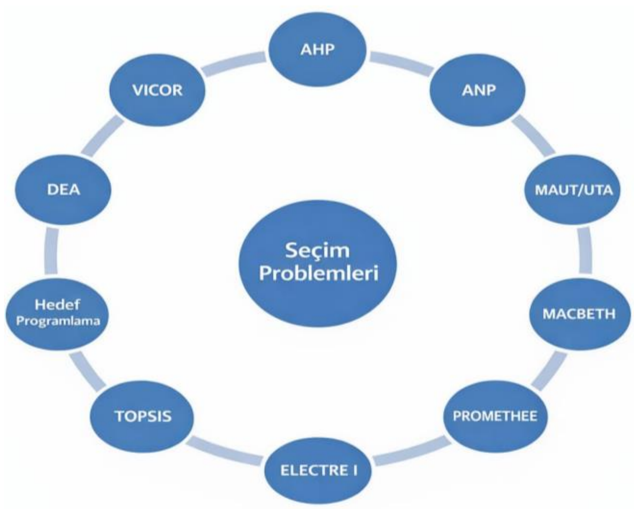

Figure 1. Multi-criteria decision-making methods used in election problems.

When these MCDM methods were searched using keywords in leading scientific publication databases such as ScienceDirect, Google Scholar, and Web of Science for the years 2015 and onwards, the following approximate results were obtained, as shown in Table 1.

Table 1. Approximate Number of Publications on Multi-Criteria Decision Making (MCDM) Methods Used in Ordering Problems from 2015 onwards.

MCDM Methods	Number of Publications
AHP	25.000+
ANP	15.000+
MAUT/UTA	1.000+
MACBETH	10+
PROMETHEE	4.000+
ELECTRE	3.000+
TOPSIS	7.000+
Goal Programming	4.000+
DEA	10.000+
VICOR	5000+

The data obtained from the study conducted with undergraduate Industrial Engineering students showed the highest compatibility with the AHP, ELECTRE, and TOPSIS methods among the multi-criteria decision-making (MCDM) methods listed in Table 1. Furthermore, these three methods are among the most preferred methods after PROMETHEE, ANP, and DEA in selection problems. Therefore, it was decided to use these methods in the study. As can be seen from Table 1, the total number of publications on Multi-Criteria Decision Making (MCDM) methods used in ranking problems exceeds 74,000 in the last 10 years. Regarding the three MCDM methods used in the presented case study, more than 35,000 studies have been conducted in the last 10 years. Given the large number of publications, it is evident that contributing to the MCDM literature is challenging. The unique aspect of the presented study can be expressed as its contribution to the literature through the combined use of these three MCDM methods.

TOPSIS is frequently used by researchers in solving multi-criteria decision-making (MCDM) problems related to business management and daily life due to the advantages it offers [5, 6]. When looking at the application areas of the TOPSIS method, Behzadian et al. (2012) stated that the main application areas of the method are supply chain management and logistics, design, engineering and manufacturing systems, business, marketing, health, safety, environment, human resources, energy, water resources management, chemical engineering and other fields; however, TOPSIS is mainly used in relation to supply chain and logistics management, design, engineering and manufacturing systems [7].

In addition, Huang (2016) conducted patient portfolio analysis [8]; Lau et al. (2016) improved customer relationship management and identified the most profitable customer for the business [9]; Mehralian et al. (2016) identified critical success factors affecting total quality management [10]; Kumar et al. (2016) identified and ranked obstacles to the maintenance of production systems [11]; Liu and Li (2015) evaluated the quality of university education [12]; Song and Zheng (2015) examined the quality of education in higher education institutions [13]; Wang and Wu (2015) identified the best web services [14]; Houska (2012) evaluated the economic performance of countries [15]; Parsaei et al. (2012) examined the order acceptance process [16]; Özgüven (2011) evaluated the performance of retailers [17]; Ghosh (2011) analyzed faculty performance [18]; Monavvarian et al. (2011) used the method to determine the information management strategy [19]; Jadidi et al. (2010) used the method to select suppliers in their studies [20].

The ELECTRE method has been used in many fields because it is used to solve assignment, selection, and ranking problems. It can be used in areas such as economics/management problems, database selection, accounting and finance, capital investment, decision support, production, marketing, planning, risk analysis, application evaluations, group decision making, facility location selection, resource allocation, policy/strategy, transportation, arms control, conflict analysis, education, environmental decisions, health, public sector, market selection, computer and information selection [21].

2. FACTORY LOCATION SELECTION VIA AHP, TOPSIS AND ELECTRE

In this phase of the study, to determine the location of the olive oil factory to be established, the population distribution data by provinces for 2023 and the olive oil production quantities for the provinces in Türkiye were first shown on maps using data obtained from TÜİK (Turkish Statistical Institute). By combining the maps obtained as a result of the analysis, a suitability map was created; thanks to the data obtained from this combination, the cities with the highest potential were determined as alternatives.

2.1 Identification of Alternative Regions

The study primarily utilized population data for Türkiye. Since the most up-to-date production data was from 2023, the population data was also prepared using 2023 as the base year for a more accurate comparison (Fig. 2).

Figure 2. Heat map of population distribution data by provinces.

With a gender distribution of 42,734,071 men and 42,638,306 women, the population of Türkiye reached a total of 85,372,377 as of 2023. Population distribution provides important clues about the demographic structure of Türkiye, and these ratios can change every year with various social and economic dynamics [22]. Istanbul, Ankara, İzmir, Bursa, and Antalya are the five most densely populated cities in Türkiye, in terms of population numbers. However, the fact that Istanbul has 2.7 times the population of Ankara has a significant impact on the selection of factory locations. According to TÜİK data, a total of 9 million decares of olive groves were recorded in Türkiye in 2023. For 2023, 73.6% of the total olive groves were for oil olives, and 26.4% were for table olives.

The clearest results regarding production data are based on 2023. Based on the analyzed data, a heat map was prepared as shown in Figure 3. Examination of the heat map reveals that Izmir province ranks among the top in production. Despite its high population density, Istanbul province remains passive in terms of production. The top 5 provinces were identified as Izmir, Mugla, Hatay, Aydın, and Manisa.

To select the correct alternative regions, these two maps were scored and intersected as shown in Figure 4. In the intersection, population and production data were ranked first. Scoring was done so that those with high population and production figures received the highest scores.

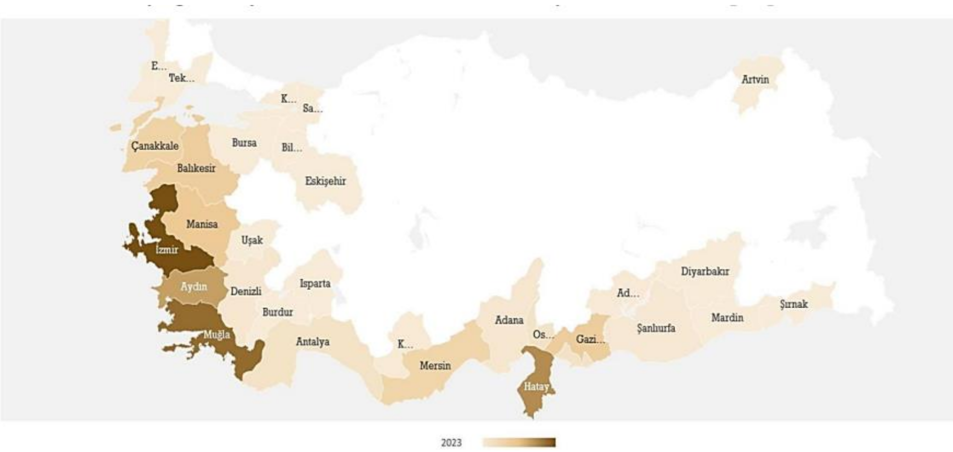

Figure 3. Heat map of olive oil production quantity by province in Türkiye.

Figure 4. Heat map of the combination of population density and production volumes.

When both population density and production quantities are examined together, an extremely high temperature is observed in Izmir. Furthermore, Izmir plays a significant role in olive oil exports due to having one of Türkiye's most developed port infrastructures. However, when population density is considered in the heat map, Istanbul has a significant advantage; its population would be very valuable for factories. Bursa, on the other hand, acts as a bridge between Istanbul and Izmir; its proximity to ports and road connections makes it a viable option. Finally, Muğla ranks fourth in Türkiye's olive production with a share of over 11%. The extensive olive groves, concentrated especially in the districts of Milas, Yatağan, and Köyceğiz, strengthen the province's position in this ranking by increasing its production capacity. This high production potential makes Muğla an important raw material center for olive oil processing plants and factories. As a result of the reasons explained, İzmir, Istanbul, Bursa, and Muğla were preferred.

The AHP, ELECTRE, and TOPSIS methods, which are part of the Multi-Criteria Decision Making (MCDM) methods, were used in selecting the location for the olive oil factory. These methods were used to determine the optimal location for establishing the factory. The application of these methods is described in this section. The criteria used in the study and their explanations are as follows.

Proximity to Raw Materials (PR): One of the most fundamental criteria when locating a production facility is proximity to raw materials. This is because the production process cannot begin without raw materials; therefore, regions rich in raw materials have a natural advantage.

Proximity to Market (PM): Market factors play a vital role in companies' location decisions. This factor consists of sub-components such as proximity to customers, market potential, and level of competition.

Workforce Potential (WP): This criterion expresses the extent to which the skilled workforce in the region can meet the needs of the facility to be established.

Technical Capabilities (TC): This refers to the level at which the chosen location can provide the necessary infrastructure and technological capacity for the production facility. This includes factors such as the availability of electricity, water, natural gas, and transportation infrastructure.

Fixed Costs (FC): Regardless of how much production volume fluctuates, the expenses a business is obligated to pay constitute fixed costs. These expenses persist even if the factory is not operating, because they are usually based on past contracts or long-term plans.

Public Supports (PS): These are financial supports offered by the state to promote economic growth and strengthen the hand of domestic producers. The main goal of these supports is not only to provide cash flow to businesses but also to increase employment and encourage entrepreneurship.

2. 2 Case Study via AHP

The application steps for the AHP method were as follows:
Step 1: Establishing the Hierarchical Model and Decision Matrix

2. 2. 1 Hierarchical Model

In this step, the purpose, criteria, and alternatives to be used in the location selection process have been determined.
Objective: To determine the most suitable location for an olive oil factory.
Criterias: Proximity to Raw Materials, Proximity to Market, Workforce Potential, Technical Capabilities, Fixed Costs (FC), Public Supports
Alternatives: The selected cities are Izmir **(A1)**, Istanbul **(A2)**, Bursa **(A3)**, and Mugla **(A4)**.

2. 2. 2 Pairwise Comparison Matrix (Decision Matrix)

In this step, the degree of importance of the criteria relative to each other is determined. The ranking is based on a scoring system of 1: Equally important, 5: Extremely important. The importance levels to be used can be listed as follows:
PM> PR> WP> FC = TC> PS

Table 2. Pairwise Comparison Matrix Between Criteria.

CRITERIAS	PM	PR	WP	FC	TC	PS
PM	1	2	3	4	4	5
PR	1/2	1	2	3	3	4
WP	1/3	1/2	1	2	2	3
FC	1/4	1/3	1/2	1	1	2
TC	1/4	1/3	1/2	1	1	2
PS	1/5	1/4	1/3	1/2	1/2	1

Step 2: Creating a Normalized Decision Matrix

Firstly, the column totals in Table 2 are shown above in Table 3.

Table 3. Decision Matrix Column Total Values.

PM	2.53
PR	4.42
WP	7.33
FC	11.50
TC	11.50
PS	17.00

2. 2. 3 Creating a Normalized Decision Matrix

The next step involves performing calculations individually for each row shown in Table 2. The formula used for this calculation is as follows:

$$a_{ij}^{norm} = \frac{a_{ij}}{\text{Column Total}} \tag{1}$$

The result obtained using this formula has been calculated, and its complete form is shown in Table 4.

Table 4. Normalized Decision Matrix.

CRITERIAS	PM	PR	WP	FC	TC	PS
PM	0.395	0.452	0.410	0.348	0.348	0.294
PR	0.198	0.226	0.273	0.261	0.261	0.235
WP	0.132	0.113	0.136	0.174	0.174	0.176
FC	0.099	0.075	0.068	0.087	0.087	0.118
TC	0.099	0.075	0.068	0.087	0.087	0.118
PS	0.079	0.057	0.045	0.043	0.043	0.059

2. 2. 4 Evaluation of the Normalized Eigenvector

Step 3: Evaluation of the Normalized Eigenvector (W)

This step is created by referencing Table 4. The arithmetic mean of each row in Table 4 is calculated and shown in Table 5. Additionally, rankings are shown based on the values obtained. The formula used to prepare the table is as follows:

$$w_i = \frac{\sum_{k=1}^{n} a_{ik}}{n} \tag{2}$$

Table 5. Weight Values and Priority Order of Criteria.

CRITERIAS	Row Total	Weight (W)	Ordering
PM	2.247	0.375	1
PR	1.454	0.242	2
WP	0.905	0.151	3
FC	0.534	0.089	4
TC	0.534	0.089	5
PS	0.326	0.054	6

2. 2. 5 Determining Eigenvalues

Step 4. Determining Eigenvalues

To measure the consistency of the matrix, the maximum eigenvalue is calculated. Using the values given in Table 6, the A x W operation is performed to create the AW vector. The letter A represents the comparison matrix, and W represents the weighting vector.

Table 6. Pairwise Comparison Matrix Column Sums Vector.

CRITERIAS	AW Vector
PM	2.294
PR	1.482
WP	0.915
FC	0.536
TC	0.536
PS	0.329
TOTAL	6.092

The AW/W ratios were calculated and tabulated using data from Table 6, as shown in Table 7 below.

Table 7. Pairwise Comparison Matrix Column Totals.

CRITERIAS	AW Vector	Weight	AW/W Ratios
PM	2.294	0.375	6.617
PR	1.482	0.242	6.124
WP	0.915	0.151	6.060
FC	0.536	0.089	6.022
TC	0.536	0.089	6.022
PS	0.329	0.054	6.093

As the final step in this process, the maximum eigenvalue calculation is performed as follows:

$$\lambda_{max} = \frac{\sum(\frac{AW}{W})}{n} \tag{3}$$

The formula is applied as follows: Looking at Table 7, the total AW/W ratio is found to be 36.438.

$$\lambda_{max} = \left(\frac{36{,}438}{6}\right) = 6.073$$

2. 2. 6 Consistency Analysis

Step 5. Consistency Analysis

The analysis performed demonstrates the consistency of the comparison matrix. First, the consistency index (CI) must be calculated. The formulated form of the consistency index is shown as follows:

$$CI = \frac{\lambda_{max} - n}{n - 1} \tag{4}$$

In this formula:

λ_{max}: It is the largest value of the matrix.

n: Number of criterias

When these calculations were performed, the largest eigenvalue of the matrix was found to be 6.073 using the formula applied after Table 7. The number of criteria is six.

CI= (6,073-6) / 5 = 0,0146

The CI value of 0.0146 obtained is the first indicator showing the consistency of the matrix. However, consistency ratio (CR) calculations are performed for acceptability analysis. At this stage, it is necessary to find the random index to find the CR value. Looking at Table 3, since the number n is 6, the random index (RI) value is 1.24. After calculating the RI value, the CR formula is shown:

$$CR = CI / RI \tag{5}$$

Applying this formula:

CR = 0.0146 / 1.24 = 0.012 is obtained. The calculated CR value is 0.012, which is much smaller than the 0.10 threshold. Therefore, the results of the analysis (location selection) are based on a solid foundation.

2. 2. 7. Calculation of Weighted Sum Scores of Alternatives and Final Decision

Step 6: Calculation of Weighted Sum Scores of Alternatives and Final Decision

In the final step of the analysis, the weights (W) representing the importance levels of the criteria are combined with the performance of the alternatives to calculate the final ranking score (Si). This score is the key parameter summarizing how suitable each city is for factory installation. To find the final score, the normalized value of each alternative based on the criterion is multiplied by the weighting coefficient of that criterion. The sum of all these values gives the overall score of the candidate. Based on the ranking scores, the alternative with the highest total score is accepted as the optimal solution, and the selection process is complete. The relevant formula is as follows:

$$S_i = \sum_{j=1}^{n} W_j \text{ x Normalized Performance}_{ij} \tag{6}$$

Before using the formula, there is a decision matrix for cities based on criteria, as shown in Table 8.

Table 8. Criterion-Based Comparison Matrix of Alternatives.

	PM	PR	WP	FC	TC	PS
A1	9	10	90	55	90	65
A2	10	3	100	100	100	0
A3	8	8	85	60	85	60
A4	4	10	40	50	50	100

The raw scores in Table 8 are normalized and multiplied by weights. The resulting city-based values are then summed to obtain the weighted total score. The resulting score is calculated as shown in Table 9.

Table 9. Final Weighting Values and Priority Ranking of Criteria.

ALTERNATIVES	Weighted Total Score (Si)	Order
A1	0.912	1
A2	0.804	2
A3	0.732	3
A4	0.640	4

The ranking resulting from the AHP analysis is as follows: Izmir, Bursa, Istanbul, and Mugla. Among the location alternatives, A1 (Izmir), which has the highest weighted total score (0.912), was determined to be the most suitable location for an olive oil factory.

2. 3 Case Study via ELECTRE

2. 3. 1 Creating the Decision Matrix (A)

Step 1: Creating the Decision Matrix (A)

The matrix to be created has been calculated and is shown in Table 8.

2. 3. 2 Creation of the Standard Decision Matrix (X)

Step 2: Creation of the Standard Decision Matrix (X)

To enable comparison of the criteria at different scales within the decision matrix, a normalized decision matrix (Table 10) was prepared using the vector norm method.

$$A_{ij} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix} \tag{7}$$

$$X_{ij} = \frac{a_{ij}}{\sqrt{\sum_{k=1}^{m} a_{kj}^2}} \tag{8}$$

Table 10. Standard Decision Matrix.

	PM	PR	WP	FC	TC	PS
A1	0.557	0.605	0.548	0.397	0.539	0.486
A2	0.619	0.181	0.609	0.723	0.599	0.000
A3	0.495	0.484	0.518	0.433	0.509	0.449
A4	0.247	0.605	0.243	0.361	0.299	0.479

2. 3. 3 Construction of the Weighted Standard Decision Matrix (Y)

Step 3. Construction of the Weighted Standard Decision Matrix (Y)

Given that the importance of evaluation criteria to the decision-maker can vary, these priorities must be incorporated into the solution. In this context, the Y matrix is calculated by processing the weights with normalized values.

$$Y_{ij} = \begin{bmatrix} W_1X_{11} & W_2X_{12} & \cdots & W_nX_{1n} \\ W_1X_{21} & W_2X_{22} & \cdots & W_nX_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ W_1X_{m1} & W_2X_{m2} & \cdots & W_nX_{mn} \end{bmatrix} \tag{9}$$

Table 11. Criterion Weights.

	PM	PR	WP	FC	TC	PS	TOTAL
Weights (W_j)	0.375	0.242	0.151	0.089	0.089	0.054	1.000

Table 12. Weighted Standard Decision Matrix (Y).

	PM	PR	WP	FC	TC	PS
A1	0.209	0.146	0.083	0.035	0.048	0.026
A2	0.232	0.044	0.092	0.064	0.053	0.000
A3	0.186	0.117	0.078	0.039	0.045	0.024
A4	0.093	0.146	0.037	0.032	0.027	0.040

2. 3. 4 Determining the Sets of Concordance (Ckl) and Discordance (Dkl)

Step 4. Determining the Sets of Concordance (C_{kl}) and Discordance (D_{kl})

The compatibility matrix is denoted as (C_{kl}) and gives the compatibility index of alternative k with respect to alternative l. This index is the sum of the weights of the criteria (Compatibility Set (C_{kl})) where alternative k is superior to alternative l.

$$i_{kl} = \sum_{j \in C_{kl}} w_j \quad (10)$$

The Incompatibility Matrix gives the incompatibility index of alternative k compared to alternative l. This index is calculated by finding the largest difference (in absolute value) between the criteria (Incompatibility Set D_{kl}) where k is worse than l. The formula for the incompatibility index is:

$$j_{kl} = \frac{\max_{j \in D_{kl}} |y_{lj} - y_{kj}|}{\max_j \max_i y_{ij} - \min_j \min_i y_{ij}} \quad (11)$$

2. 3. 5 Formation of Consistency (C) and Dissimilarity Matrices (D)

Step 5. Formation of Consistency (C) and Dissimilarity Matrices (D)

The process of constructing a matrix C that does not take values in the equation k=1 and is of type m x m relies on compatibility sets.

Table 13. Consistency Matrix (C).

	A1	A2	A3	A4
A1	-	0.574	0.625	0.911
A2	0.429	-	0.714	0.661
A3	0.375	0.286	-	0.786
A4	0.089	0.339	0.232	-

Table 14. Dissimilarity Matrix (D).

	A1	A2	A3	A4
A1	-	0.512	0.438	0.217
A2	0.684	-	0.291	0.531
A3	0.556	0.662	-	0.301
A4	0.841	0.591	0.699	-

2. 3. 6 Construction of Concordance (F) and Discordance (G) Matrices

Step 6. Construction of Concordance (F) and Discordance (G) Matrices

Comparing the values in the fit matrix (C_{kl}) with the threshold value (C) found using Eq. 12 reveals the m x m dimensional fit superiority matrix (F).

$$C = \frac{1}{m(m-1)} \sum_{k=1}^{m} \sum_{l=1}^{m} C_{kl} \quad (12)$$

C_{kl}=0.515

Table 15. Concordance Matrix (F).

	A1	A2	A3	A4	Total Dominance
A1	-	1	1	1	3
A2	0	-	1	1	2
A3	0	0	-	1	1
A4	0	0	0	-	0

D_{kl}= 0.673

Table 16. Discordance Matrix (G).

	A1	A2	A3	A4	Total Dominance
A1	-	0	1	1	2
A2	1	-	0	0	1
A3	1	1	-	0	2
A4	0	0	0	-	0

2. 3. 7 Construction of the Total Dominance Matrix (E)

Step 7. Construction of the Total Dominance Matrix (E)

The Total Dominance Matrix (E) is formed by multiplying the F_{kl} and G_{kl} components. This m x m matrix, which is shaped according to the C and D matrices, has elements that are either 0 or 1.

Table 17. Cell-Based Spreadsheet.

k	l	F_{kl}	G_{kl}	$E_{kl} = F_{kl} \times G_{kl}$
A1	**A2**	1	0	0
A1	**A3**	1	1	1
A1	**A4**	1	1	1
A2	**A1**	0	0	0
A2	**A3**	1	1	1
A2	**A4**	0	0	0
A3	**A1**	0	1	0
A3	**A2**	0	0	0
A3	**A4**	1	1	1
A4	**A1**	0	0	0
A4	**A2**	0	0	0
A4	**A3**	0	1	0

Table 18. Total Dominance Matrix.

	A1	A2	A3	A4	Total Dominance
A1	-	0	1	1	2
A2	0	-	1	0	1
A3	0	0	-	1	1
A4	0	0	0	-	0

2. 3. 8 Determining the Order of Importance of Decision Points

Step 8. Determining the Order of Importance of Decision Points

The rows and columns in the E matrix represent the alternatives being evaluated. Ranking is done by following the dominance chain in the graph and considering the number of dominances each alternative has.

Table 19. Determining Superiority Numbers.

ALTERNATIVES	Superiority Number (Dominance)	Number of Losses (Defeat)	Net = Dominance - Defeat
A1	2	0	+2
A2	1	0	+1
A3	1	2	-1
A4	0	2	-2

According to ELECTRE methodology, Izmir has the highest correlation with olive oil factory locations.

2. 4 Case Study via TOPSIS

In this section, TOPSIS was applied to rank the alternative locations identified for the olive oil factory. The criterion weights used in the TOPSIS analysis are the weights obtained with AHP in section 2.2. No additional weighting was done during the TOPSIS phase. Thus, inter-method consistency was ensured. In this study, the FC criterion was considered as a cost-oriented criterion, while all other criteria were evaluated as benefit-oriented criteria.

2. 4. 1 Decision Matrix (A)

Step 1: Decision Matrix (A)

The decision matrix used in the TOPSIS analysis consists of raw data from alternative locations (Izmir, Istanbul, Bursa, and Mugla) and evaluation criteria. The implemented version of this step is shown in Table 8.

2. 4. 2 Normalized Decision Matrix (R)

Step 2: Normalized Decision Matrix (R)

To enable comparison of criteria at different scales within the decision matrix, a normalized decision matrix was created using the vector norm method. This step is shown in Table 4.

2. 4. 3 Weighted Normalized Decision Matrix (V)

Step 3: Weighted Normalized Decision Matrix (V)

The weighted normalized decision matrix was obtained by multiplying the AHP-based weights (w_i) by the normalized criterion values. The final matrix is shown in Table 12.

2. 4. 4 Positive and Negative Ideal Solutions

Step 4: Positive and Negative Ideal Solutions (A^*, A^-)

The positive ideal solution (A^*) was created by taking maximum values for the benefit-oriented criteria and minimum values for the cost-oriented criterion, FC. The negative ideal solution (A^-) was determined in reverse. The values for the positive and negative ideal solutions are shown in Table 20.

Table 20. Positive Ideal (A^*) and Negative Ideal (A^-) Solution Values.

	PM	PR	WP	FC	TC	PS
Positive (A^*)	0.232	0.147	0.092	0.032	0.053	0.041
Negative (A^-)	0.093	0.044	0.037	0.064	0.027	0.000

2. 4. 5 Calculating Distances and Relative Proximity

Step 5: Calculating Distances and Relative Proximity

The distances of all alternatives to the positive and negative ideal solutions were calculated using the Euclidean distance method. Then, the relative proximity coefficient (C^*i) was calculated for each alternative. The results are presented in Table 21.

Table 21. Results of Distances and Relative Proximity (C^*i) of Alternatives to Ideal Solutions.

ALTERNATIVES	S^*	S^-	C^*i
A1	0.029	0.168	0.850
A2	0.060	0.132	0.687
A3	0.115	0.152	0.569
A4	0.152	0.115	0.431

When the C^*i results are sorted from largest to smallest, the alternative regions are ranked as follows: Izmir, Bursa, Istanbul and Mugla. Based on this result, Izmir (A1) was concluded as the most suitable region using the TOPSIS method.

Table 22. AHP, ELECTRE, and TOPSIS Priority Rankings.

Priority Rankings	AHP	ELECTRE	TOPSIS
4. Priority	A4	A4	A4
3. Priority	A2	A3	A2
2. Priority	A3	A2	A3
1. Priority	A1	A1	A1

3. CONCLUSION AND RECOMMENDATIONS

This study utilized multi-criteria decision-making (MCDM) methods to determine the optimal location for an olive oil factory. Simultaneously, heat maps were created using the data to identify alternatives. The evaluations considered not only olive production quantity but also other factors influencing investment decisions, such as market size, labor potential, technical infrastructure, costs, and government support. This allowed for a more realistic and holistic assessment of the site selection process. Using AHP, ELECTRE, and TOPSIS methods, İzmir province was identified as the most suitable alternative in all analyses. İzmir's proximity to raw material sources, along with its developed market and infrastructure, contributed to this result. Similar results obtained from different methods support the consistency of the study.

When AHP, ELECTRE, and TOPSIS methods were applied, the priority rankings of the alternatively selected cities for each method are available in Table 22. As a result of all the applied methods, city A1 (Izmir), which is commonly regarded as the top priority, was selected as the most suitable location for the factory.

The study's findings emphasize the importance of considering not only production volume but also other factors, such as market size, workforce potential, and technical capabilities, when selecting a factory location. The fact that Izmir ranked first in the methods used indicates that it possesses a significant strategic advantage in the evaluated factors. Increasing the number of alternative cities in future studies could yield more reliable results when viewed from a national perspective in Türkiye. The data used in this study is from 2023. Re-analyzing with updated data from different years could provide a broader perspective. Finally, adding new factors such as environmental impacts and sustainability to future studies could help in making more balanced decisions from a social and environmental standpoint.

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Authors' Contributions

No	Full Name	ORCID ID	Author's Contribution
1	Ozan Ateş	0000-0003-4178-2603	1, 2, 4
2	İrem Saydam	0009-0007-3010-5670	2, 3, 4
3	Selin Çağlar	0009-0003-2473-7234	2, 3, 4
4	Yunus Emre Öztürk	0009-0006-1014-4384	2, 3, 4
1-Study Design 2-Data Collection 3-Data Analysis and Interpretation 4- Manuscipt Writing			

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