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RESEARCH ARTICLE

A Hybrid Fuzzy Multi-Criteria Decision-Making Approach for Data Center Location Selection

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Abstract

In today's world, the fact that information applications have become an indispensable part of life with the effect of the developments in information technologies has led to a huge rate of data production and usage. As a result of this, the need for data centers has increased. Although Turkey is a country with advantages that can play a leading role in the field of data centers in the region where it is located, it has some disadvantages too. Some of these disadvantages are natural disasters index, climate index, energy index, accessibility index, human capital and quality of life index (HCLQ). In this context, these disadvantages are considered as criteria for data center location selection problem. In this study, criteria weights were determined by fuzzy DEMATEL (The Decision Making Trial and Evaluation Laboratory) method in the problem solving and alternatives (81 provinces) were ranked using EDAS (Evaluation based on Distance from Average Solution) method. According to the results, it was found that Istanbul is the best alternative in data center location selection.

Keywords: Data Center, Location Selection, Fuzzy DEMATEL, EDAS

1.Introduction

The role of computer and internet technologies in our life is increasing day by day. Information infrastructures created to ensure the technology to be accessed by everyone, communication technologies and data stored for users allowed data centers to be created. Data centers are also called computer rooms or system rooms. Access to the data held in the data centers and services at any time requires an uninterrupted service delivery. Therefore, the necessary infrastructure should be designed redundantly and stably.

To ensure that the facility operates without any problem, meets all mandatory requirements and ensures high profitability with low cost; many factors should be considered in the location selection of the facility and then the decision should be made. Since data centers are very large structures, it is not possible to relocate them after the facility is completed. Therefore, the location selection problem of data centers is an important decision problem. In this context, natural disasters index, climate index, energy index, accessibility index and human capital and life quality index (HCLQ) criteria of 81 provinces are taken into consideration for the location selection problem of the data center in Turkey.

There are many studies in different fields in the literature about data centers. The studies on data center location selection we deal with that are conducted by different methods are given below. Faiz and Noor-E-Alam [1] used two mixed integer linear programming for data center location problem. In the first model, they aimed to determine the locations without a data center, capacity, and demands to the data centers. In the second model, they examined the decision problem where the demands were met by the existing data centers. They solved models in CPLEX using AMPL programming language. Daim et al. [2] developed a model to investigate the various factors (financial, environmental, social, geographic, etc.) that an organization should consider when selecting a city for its own data center building. In this model, they applied multi-criteria decision making (MCDM) using the analytic hierarchy process (AHP) and hierarchical decision model (HDM). Liu et al. [3] investigated the optimal locations of the Chinese railway to data centers, considering the transmission distance and the volume of each railway office. They used the PSO algorithm for the optimal location selection problem of data centers. Lv et al. [4] discussed container deployment issues and identified the problem in two stages to reduce communication costs and to balance resource use in large-scale data centers. The first is the problem of container placement and the second is the problem of container assignment. Ounifi et al. [5] offered an efficient model based on mixed integer linear programming (MILP) for the data center location problem. They applied the decreasing balance method to calculate the depreciation costs of the selected data centers. Miguel T Covas et al. [6] used multi-criteria decision-making tools and IRIS software package to identify data center zones. They also calculated ELECTRE TRI values for the sequencing method. Abbasov et al. [7] identified important risk factors to determine the location of data centers in their study. After determining these risk factors, they offered the solution to the problem by using fuzzy linguistic variables for the optimal location. Chang et al. [8] desire to merge several data centers in their study. In this problem, they used the integer programming model to determine the optimal data center location. Miguel Trigueiros Covas et al. [9] conducted an overall assessment of the locations of data centers in Portugal. Using information from experts, they offered a method for

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identifying a new optimal data center area. They combined the data into a geographic information system (GIS). According to the results, they could not find the most suitable solution for the location of data centers. Jaumard et al. [10] aimed to select the optimal locations to build data centers and also to determine the required number of servers in their study. They used CPLEX optimization software in the solution. Goścień et al. [11] discussed the problem of data center location and routing traffic demands in the elastic optical network. They used two different modeling and optimization methods for this problem.

2. Methods

Multi-criteria decision making (MCDM) techniques are used to help select the best alternative under more than one criterion to conduct the decision-making process correctly. There are many studies in different areas using MCDM techniques. The some of these studies: smart wristband selection [12], ERP deployment strategy selection [13],[14], evaluation of framed building types [15], strategic alliance partner selection in third-party logistics [16], logistics center location selection [17], the medical company selection [18], location selection problem for underground waste containers [19], warehouse location selection problem [20], industrial engineering sector choosing [21], personnel selection [22], location selection for a yarn factory [23].

In this study, a solution is proposed using Fuzzy DEMATEL and EDAS methods among multi-criteria decision-making methods to help data center location selection process.

In this study, criteria weights and significance levels between criteria were determined by the fuzzy DEMATEL method, all cities in Turkey were taken as alternative and the EDAS method was used to select from among these alternatives.

2.1. Fuzzy DEMATEL Method

DEMATEL method was developed by the Geneva Battelle Memorial Institute Science and Human Relations program between 1972 and 1976. This method was used to investigate and analyze the interaction between complex problem groups [24].

DEMATEL method provides the opportunity to solve and analyze the problem as a draft by determining which of the criteria that cause a complex and intertwined problem are the affected ones and which are the affecting ones. Its main purpose is to visualize complex cause and effect relations and to obtain significant results. However, it is difficult to determine the degree of interaction between the factors in these relations. The reason for this is that it is very difficult for experts to quantify the interaction between the factors. Therefore, Lin and Wu extended the DEMATEL method to a fuzzy environment [25].

The steps of the fuzzy DEMATEL method are as follows: [26].

Step 1: Determination of criteria and fuzzy scale

In this step, first of all, it is necessary to determine the criteria to be used in practice and the significant relations between the criteria by the expert group. It is very difficult to determine the degree of interaction between the factors in these relations. The reason for this is that it is very difficult for experts to quantify the interaction between the factors. Therefore, the fuzzy scale was proposed by Li. The fuzzy scale corresponding to linguistic terms is given in Table 1. Linguistic terms are expressed in triangular fuzzy numbers [27].

Table 1. Fuzzy Linguistic Scale

Linguistic Terms	Fuzzy Provisions
Very Poor Effect	(0.00;0.00;0.25)
Poor Effect	(0.00;0.25;0.50)
Normal Effect	(0.25;0.50;0.75)
Good Effect	(0.50;0.75;1.00)
Very Good Effect	(0.75;1.00;1.00)

Step 2: Creating a direct correlation matrix

A paired comparison matrix is created by each expert in the expert group using the linguistic scale given in Table 1 to determine the level of relations between C={C_1, C_2 .... C_n } criteria of decision. Assuming that the decision group consists of p number of experts, the p number of the decision matrix is obtained. As a result of comparisons, the Fuzzy direct correlation matrix ("$\tilde{Z}$") is obtained and is shown with Equation (1) [28].

$$\tilde{Z}^{(k)} = \begin{bmatrix} 0 & \tilde{Z}_{12}^{(k)} & \cdots & \tilde{Z}_{1n}^{(k)} \\ \tilde{Z}_{21}^{(k)} & 0 & \cdots & \tilde{Z}_{2n}^{(k)} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{Z}_{n1}^{(k)} & \tilde{Z}_{n2}^{(k)} & \cdots & 0 \end{bmatrix} \quad k = 1,2,\dots p \qquad (1)$$

$\tilde{Z}_{ij}$ = (l_{ij}, m_{ij}, u_{ij}) indicates the effecting degree of ith criteria on jth criteria.

Step 3: Creating a normalized direct correlation matrix

$$\tilde{x}_{ij}^{(k)} = \frac{\tilde{z}_{ij}^{k}}{r^k} = \left(\frac{l_{ij}^{k}}{r^k}, \frac{m_{ij}^{(k)}}{r^k}, \frac{u_{ij}^{(k)}}{r^k}\right) \qquad (2)$$

$$r^{(k)} = \max_{1<i<n}\left(\sum_{j=1}^{n} u_{ij}^{k}\right) \qquad (3)$$

Using Equation (3), "u" values in each criterion representing the last of the triangular fuzzy numbers are added as columns and a single value is obtained for each column. The largest of these values is selected and this value is defined as "r". The whole matrix is divided by the resulting "r" value and the normalized direct correlation matrix ("$\tilde{X}$ ") is represented by Equation (4).

$$\tilde{X} = \begin{bmatrix} \tilde{X}_{11} & \tilde{X}_{12} & \dots & \tilde{X}_{1n} \\ \tilde{X}_{21} & \tilde{X}_{22} & \cdots & \tilde{X}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{X}_{n1} & \tilde{X}_{n2} & \dots & \tilde{X}_{nn} \end{bmatrix} \qquad (4)$$

Step 4: Creating the total correlation matrix

In this step, the total correlation matrix will be created using Equation (5).

$$\tilde{T} = \tilde{X} + \tilde{X}^2 + \tilde{X}^3 + \cdots = \sum_{i=1}^{\infty} \tilde{X}^i = \tilde{X}(1 - \tilde{X})^{-1} \qquad (5)$$

Since it is difficult to apply this equation to the whole matrix, three matrices are obtained by applying Equation (5) to triangular fuzzy numbers separately. After this process is repeated for all three matrices, the results are combined and " $\tilde{T}$" matrix represented by Equation (6) is obtained (Organ, 2013).

$$\tilde{T} = \begin{bmatrix} \tilde{T}_{11} & \tilde{T}_{12} & \dots & \tilde{T}_{1n} \\ \tilde{T}_{21} & \tilde{T}_{22} & \dots & \tilde{T}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{T}_{n1} & \tilde{T}_{n2} & \dots & \tilde{T}_{nn} \end{bmatrix} \qquad (6)$$

Step 5: Determination of sender and recipient groups

After obtaining the total correlation matrix $(\tilde{T})$, $\tilde{D}_i + \tilde{\tilde{R}}_i$ and $\tilde{D}_i - \tilde{\tilde{R}}_i$ values are calculated by Equitation (7) to give $\tilde{D}_i$ value by the total of column elements in the matrix and $\tilde{\tilde{R}}_i$ value by the total of row elements in the matrix.

$$\tilde{D}_i = \sum_{i=1}^{n} \tilde{T}_{ij} \qquad (i = 1,2, \dots, n) \qquad (7)$$

$$\tilde{R}_i = \sum_{j=1}^{n} \tilde{T}_{ij} \qquad (j = 1,2, \dots, n)$$

D + R and D − R values are calculated by using Equation (7) for each criterion and D - R values obtained, and the effect and relation level of each criterion with other criteria is determined using the obtained D + R and D − R. Some criteria have a positive value for D − R value. These criteria have a higher effect and priority over other criteria. Such criteria are defined as effecting criteria. Some criteria also have a negative value for D − R value. Such criteria have lower effect and priority over other criteria and are defined as affected criteria.

D + R values indicate the level of the relations between the criteria. Criteria with high D + R values are more correlated to other criteria. Criteria with low D + R values are less correlated with other criteria [29].

Step 6: Defuzzification Process

Defuzzification process is applied to make the obtained D + R and D−R values as a single value. The abbreviation "def" on the formulas in Equation (8) is the abbreviation of "defuzzification" term [14]. The "defuzzification" process is obtained using Equation (8).

$$D_i^{def} + R_i^{def} = \frac{1}{4}(l + 2m + u) \quad (8)$$

$$D_i^{def} - R_i^{def} = \frac{1}{4}(l + 2m + u)$$

Step 7: Obtaining cause-effect relation diagram

It is analyzed by drawing a cause-effect relation diagram with values obtained from the defuzzification method.

The cause-effect relation diagram has D + R values on the horizontal axis and D−R values on the vertical axis.

Step 8: Obtaining weights

The weight of each criterion is calculated using Equation (9) and Equation (10).

$$w_i = ((D_i^{def} + R_i^{def})^2 + (D_i^{def} - R_i^{def})^2)^{1/2} \quad (9)$$

$$W_i = \frac{w_i}{\sum_{i=1}^{n} w_i} \quad (10)$$

2.2. EDAS Method

EDAS method (Evaluation Based On Distance From Average Solution) is a method that was developed by Ghorabaee et al. in 2015 and considers the average solution in choosing the best alternative [30].

EDAS method consists of 6 steps: [30]

Step 1: Creating a decision matrix

In this step, significant relations between alternatives and criteria are determined by the expert group.

$$X = [X_{ij}]_{n\times m} \begin{bmatrix} X_{11} & X_{12} & \cdots & X_{1m} \\ X_{21} & X_{22} & \cdots & X_{2m} \\ \vdots & \vdots & \vdots & \vdots \\ X_{n1} & X_{n2} & \cdots & X_{nm} \end{bmatrix} \quad (11)$$

x_{ij}= indicates the performance value of ith alternative by jth criteria.

Step 2: Creating Average Solution Matrix (AV_j)

The average solution matrix (AV) is calculated by averaging all criteria values.

$$AV = [AV_j]_{1*m} \quad (12)$$

AV_j = indicates the average of jth criteria and is calculated by Equation (13).

$$AV_j = \frac{\sum_{i=1}^{n} X_{ij}}{n} \quad (13)$$

Step 3: Creating Positive Distance From Average (PDA) and Negative Distance From Average (NDA) [31].

$$PDA = PDA_{ij\ n\times m} \quad (14)$$

$$NDA = NDA_{ij\ n\times m} \quad (15)$$

For each criterion, it is calculated differently depending on the benefit type or cost type of criteria.

If the criteria are the benefit type;

$$PDA_{ij} = \frac{\max(0,(X_{ij} - AV_j))}{AV_j} \quad (16)$$

$$NDA_{ij} = \frac{\max(0,(AV_j - X_{ij}))}{AV_j} \quad (17)$$

If the criteria are the cost type;

$$PDA_{ij} = \frac{\max(0,(AV_j - X_{ij}))}{AV_j} \quad (18)$$

$$NDA_{ij} = \frac{\max(0,(X_{ij} - AV_j))}{AV_j} \quad (19)$$

Step 4: Calculation of Weighted total positive value (SP_i) and Weighted total negative value (SN_i) for all alternatives

The weighted total positive value (SP_i) of ith alternative and the weighted total negative value (SN_i) of ith alternative are calculated by the following formulas.

The criterion weights obtained from Fuzzy DEMATEL method are used for w_j values in the formulas shown in Equation (20) and Equation (21).

$$SP_i = \sum_{j=1}^{m} wj * PDA_{ij} \quad (20)$$

$$SN_i = \sum_{j=1}^{m} wj * NDA_{ij} \quad (21)$$

Step 5: Normalizing SP_i and SN_i values

$$NSP_i = \frac{SP_i}{\max(SP_i)} \quad (22)$$

$$NSN_i = 1 - \frac{SN_i}{\max(SN_i)} \quad (23)$$

SP_i and SN_i values obtained in step 4 are normalized using Equation (22) and Equation (23).

Step 6: Calculation of the Evaluation score (AS_i)

The evaluation scores for each alternative are calculated by Equation (24) given below.

$$AS_i = \frac{1}{2} * (NSP_i + NSN_i) \quad (24)$$

$0 \le AS_i \le 1$ values are taken.

The alternative with the highest AS_i value is selected as the best alternative among the alternatives.

3. Finding

In this study, during the determination of the relations and priorities between the criteria, the DEMATEL method, which determines the relations of the criteria and their effects on each other in order of priorities, was used. Since it is difficult to quantitatively express the interaction between criteria here, the Fuzzy DEMATEL method was used. EDAS method was used to select from alternatives.

3.1. Determination of Criterion Weights by Fuzzy DEMATEL Method Method

Step 1: Determination of criteria and fuzzy scale

The criteria used in the evaluation were determined by the expert group as natural disaster index (C_1), climate index (C_2), energy index (C_3), accessibility index (C_4), human capital and life quality index (HCLQ) (C_5). The explanations of the criteria are shown in Figure 1.

This study was conducted to reveal which data center investments, an important and indispensable part of the IT sector, should be suitable. In this context, first of all, a group of 3 experts was formed. The study was evaluated on 81 alternative provinces and 5 criteria with the evaluation of this expert group. The verbal expression of the paired comparisons of decision-makers between criteria according to the fuzzy linguistic terms in Table 1 is given in Table 2.

Table 2. Paired Comparison Matrix of Decision Makers with Verbal Expressions

Criteria	C_1	C_2	C_3	C_4	C_5
C_1	0	Very Good Effect	Good Effect	Good Effect	Very Good Effect
C_2	Normal Effect	0	Normal Effect	Good Effect	Good Effect
C_3	Poor Effect	Normal Effect	0	Good Effect	Good Effect
C_4	Poor Effect	Poor Effect	Poor Effect	0	Normal Effect
C_5	Poor Effect	Poor Effect	Poor Effect	Poor Effect	0

Step 2: Creating a direct correlation matrix

The direct correlation matrix is obtained by arranging the triangular fuzzy number values corresponding to the fuzzy linguistic terms in Table 1.

Step 3: Creating a normalized direct correlation matrix.

A normalized direct correlation matrix is obtained using Equation (2) and Equation (3) and is shown in Table 3.

Step 4: Creating a total correlation matrix

The data obtained using Equation (5) is shown in Table 4.

Step 5: Determination of sender and recipient groups

$D + R$ and $D - R$ values are calculated to give D value by the total of column elements in the matrix and R value by the total of row elements in the matrix.

Step 6: Defuzzification Process

Defuzzification process is applied using Equation (8) and it is shown in Table 5.

According to Table 5, C4 and C5 criteria are more affected than other criteria because they have positive $D - R$ values.

C1, C2, and C3 criteria are more affected than other criteria because they have negative D-R values.

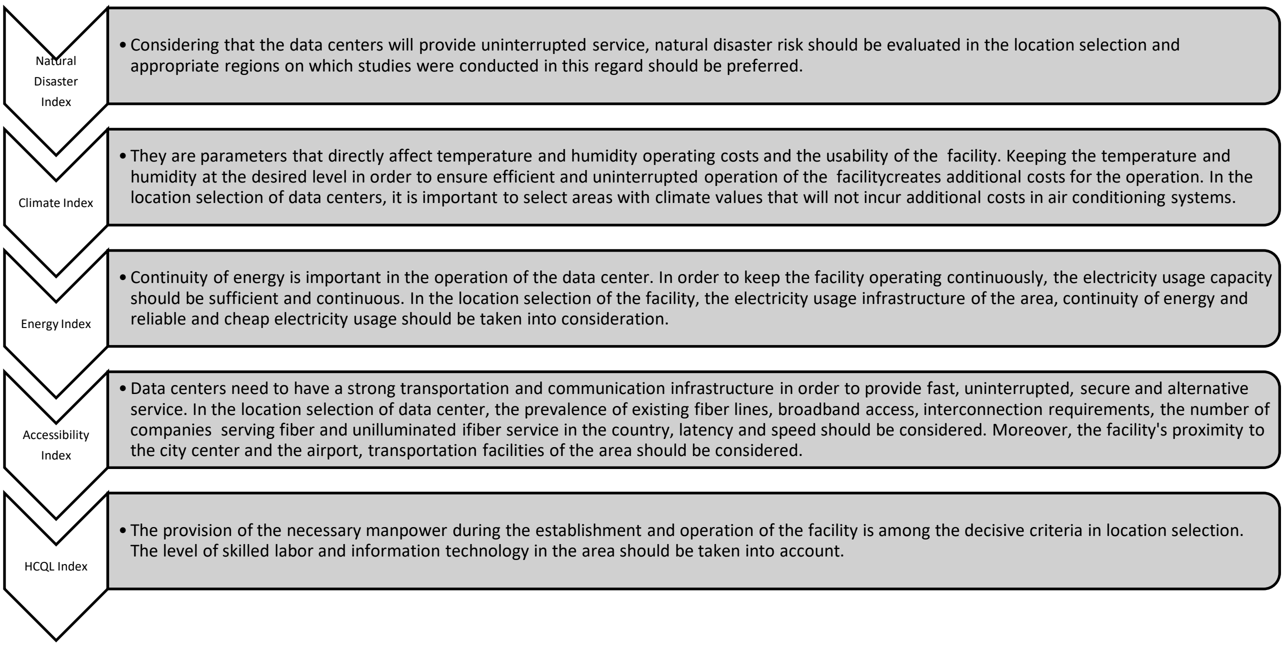

Figure 1: The explanations of the criteria

Table 3. Normalized Direct Correlation Matrix

CRITERIA	C1			C2			C3			C4			C5		
C1	0.00	0.00	0.00	0.20	0.27	0.27	0.13	0.20	0.27	0.13	0.20	0.27	0.00	0.27	0.27
C2	0.07	0.13	0.20	0.00	0.00	0.00	0.07	0.13	0.20	0.13	0.20	0.27	0.07	0.20	0.27
C3	0.00	0.07	0.13	0.07	0.13	0.20	0.00	0.00	0.00	0.13	0.20	0.27	0.00	0.20	0.27
C4	0.00	0.07	0.13	0.00	0.07	0.13	0.00	0.07	0.13	0.00	0.00	0.00	0.00	0.13	0.20
C5	0.00	0.07	0.13	0.00	0.07	0.13	0.00	0.07	0.13	0.00	0.07	0.13	0.00	0.00	0.00

Table 4. Total Correlation Matrix

CRITERIA	C1			C2			C3			C4			C5		
C1	0.01	0.14	0.58	0.21	0.41	0.88	0.15	0.34	0.88	0.18	0.41	1.04	0.01	0.51	1.10
C2	0.07	0.22	0.68	0.02	0.14	0.59	0.08	0.24	0.76	0.16	0.34	0.94	0.21	0.38	0.99
C3	0.00	0.15	0.59	0.07	0.23	0.71	0.01	0.11	0.54	0.14	0.32	0.88	0.28	0.35	0.93
C4	0.00	0.11	0.47	0.00	0.14	0.52	0.00	0.13	0.52	0.00	0.09	0.50	0.17	0.23	0.70
C5	0.00	0.11	0.44	0.00	0.13	0.49	0.00	0.12	0.49	0.00	0.14	0.58	0.08	0.10	0.50

Table 5. Defuzzification Process

CRITERIA	D+R	D-R
C1	3.247	-1.100
C2	3.177	-0.386
C3	2.944	-0.287
C4	2.832	0.691
C5	2.974	1.082

Step 7: Obtaining weights

Weight values for each criterion were calculated using Equation (9) and Equation (10) with the obtained D + R and D-R values and the results are given in Table 6.

Table 6.Weighting

Criteria	D+R	D-R	w	W	Criteria Priorities
C1	3.247	-1.100	3.428	0.219	1
C2	3.177	-0.386	3.201	0.204	2
C3	2.944	-0.287	2.958	0.189	4
C4	2.832	0.691	2.915	0.186	5
C5	2.974	1.082	3.165	0.202	3
		TOTAL	15.666	1.000	

When the data obtained from Table 6 are evaluated, the most important criterion for data center location selection is determined as a natural disaster index (C_1).

3.2. Data Center Location Selection with EDAS Method

In this study, the EDAS method, which considers the average solution in data center location selection, is used.

Step 1: Creating a decision matrix

When creating a decision matrix in data center location selection to be made by the EDAS method, the data in the study of Toprak were used [32].

Step 2: Creating a average solution matrix (AV)

AV values of each criterion were calculated using Equation (13) and they are shown in Table 7.

Step 3: Calculation of Positive Distance From Average (PDA) and Negative Distance From Average (NDA)

At this stage, they are calculated using Equation (16) and Equation (17) by criteria of benefit type, using Equation (18) and Equation (19) criteria of cost type and they are shown in Tables 8 and 9.

Here, natural disaster index, climate index, energy index, accessibility index and human capital and life quality index are defined as benefit type criteria. The greater the index values for all disclosed index values, the greater the suitability for location selection for the respective alternative is.

Step 4: Calculation of weighted total positive value (SP_i) and a weighted total negative value (SN_i) for all alternatives

Equation (20) and Equation (21) were used in the calculation of (SP_i) and (SN_i) values. The criterion weights in Table 6 are used for w_j values in these equations.

Step 5: Normalizing SP_i and SN_i values

Equation (22) and Equation (23) were used to normalize SP_i and SN_i values and the results are given in Table 10.

Step 6: Calculation of the evaluation score (AS_i)

The evaluation score (AS_i) for each alternative was calculated using Equation (24) and the results are given in Table 10.

The most important criterion was determined by Fuzzy DEMATEL as Natural Disaster Index. According to the evaluation score (AS_i) calculated in the result table, İstanbul ($AS_i = 0.709$) was chosen as the best alternative.

Table 7. Comparison Matrix of Expert Group by Alternatives

Province No	Province Name	C1	C2	C3	C4	C5
1	Ankara	99.742	40.903	21.971	71.005	79.706
2	Artvin	75.868	62.901	77.039	23.073	43.062
3	Eskişehir	99.887	38.564	46.182	52.644	62.981
4	İstanbul	99.669	17.971	16.227	98.064	86.828
⋮	⋮	⋮	⋮	⋮	⋮	⋮
40	Yozgat	99.580	49.452	43.077	18.757	28.573
41	Rize	96.619	25.699	46.373	33.837	45.263
42	Sivas	97.384	48.869	31.708	26.920	38.031
⋮	⋮	⋮	⋮	⋮	⋮	⋮
79	Şırnak	99.620	31.744	17.548	11.619	16.873
80	Agrı	97.224	56.669	0.000	3.193	12.467
81	Bitlis	62.008	47.303	0.000	10.576	16.293
Total		7725.014	3162.451	2910.761	2693.238	3258.068
Average		95.371	39.043	35.935	33.250	40.223

Table 8. Positive Distance From Average

Province No	Province Name	C1	C2	C3	C4	C5
1	Ankara	0.046	0.048	0.000	1.136	0.982
2	Artvin	0.000	0.611	1.144	0.000	0.071
3	Eskişehir	0.047	0.000	0.285	0.583	0.566
4	İstanbul	0.045	0.000	0.000	1.949	1.159
⋮	⋮	⋮	⋮	⋮	⋮	⋮
40	Yozgat	0.044	0.267	0.199	0.000	0.000
41	Rize	0.013	0.000	0.290	0.018	0.125
42	Sivas	0.021	0.252	0.000	0.000	0.000
⋮	⋮	⋮	⋮	⋮	⋮	⋮
79	Şırnak	0.045	0.000	0.000	0.000	0.000
80	Agrı	0.019	0.451	0.000	0.000	0.000
81	Bitlis	0.000	0.212	0.000	0.000	0.000

Table 9. Negative Distance From Average

Province No	Province Name	C1	C2	C3	C4	C5
1	Ankara	0.000	0.000	0.389	0.000	0.000
2	Artvin	0.204	0.000	0.000	0.306	0.000
3	Eskişehir	0.000	0.012	0.000	0.000	0.000
4	İstanbul	0.000	0.540	0.548	0.000	0.000
⋮	⋮	⋮	⋮	⋮	⋮	⋮
40	Yozgat	0.000	0.000	0.000	0.436	0.290
41	Rize	0.000	0.342	0.000	0.000	0.000
42	Sivas	0.000	0.000	0.118	0.190	0.055
⋮	⋮	⋮	⋮	⋮	⋮	⋮
79	Şırnak	0.000	0.187	0.512	0.651	0.581
80	Agrı	0.000	0.000	1.000	0.904	0.690
81	Bitlis	0.350	0.000	1.000	0.682	0.595

Table 10. Result Table

Province No	Province Name	SP_i	SN_i	NSP_i	NSN_i	AS_i
1	Ankara	0.429	0.708	0.073	0.143	0.425
2	Artvin	0.355	0.585	0.102	0.198	0.392
3	Eskişehir	0.287	0.473	0.003	0.005	0.239
4	İstanbul	0.607	1.000	0.214	0.417	0.709
⋮	⋮	⋮	⋮	⋮	⋮	⋮
40	Yozgat	0.102	0.168	0.140	0.272	0.220
41	Rize	0.086	0.142	0.070	0.136	0.139
42	Sivas	0.056	0.092	0.069	0.134	0.113
⋮	⋮	⋮	⋮	⋮	⋮	⋮
79	Şırnak	0.010	0.016	0.373	0.728	0.372
80	Agrı	0.096	0.159	0.496	0.969	0.564
81	Bitlis	0.043	0.071	0.512	1.000	0.536

4. Results

Nowadays, the need for uninterrupted, scalable, manageable, reliable data centers that provide high-level security, 24/7 service, which is equipped with advanced technology infrastructure is increasing for the public and private sector to meet the increasing demands of information technologies. Especially, public institutions cannot provide all of the devices that will ensure human resource, security systems, broadband access, renewed technical infrastructure and business continuity adorned with quality information technologies due to lack of resources. In today's world where information is the most expensive, continuity should be expected in the e-government structure, which has all kinds of hardware and software that enable the storage, transportation, protection, and analysis of information. In this context, the location of the data center, which stands out as a great need, is of great importance.

In this study, the answer to the question of where the data center can be built with the least cost was sought. For this purpose, considering factors such as natural disasters, climate, energy, accessibility, human capital and life quality having a direct effect on the building of data center a location selection problem in Turkey on a province basis was investigated.

In the solution stages of this problem, it was planned to use the DEMATEL method to determine the relations and importance levels between the criteria, however, Fuzzy DEMATEL was preferred because it is difficult to quantitatively determine how much one criterion affects another criterion. EDAS method, which considers the average solution, was preferred for the selection of the province with the best evaluation score among the alternatives. According to fuzzy DEMATEL method, Natural Disaster Index was found to be the most important criterion in data center location selection. According to the EDAS method results, Istanbul was chosen as the best alternative with an evaluation score of 0.709.

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