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Evaluation of Stadium Locations Using AHP and TOPSIS Methods

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AHP ve TOPSIS Yöntemleriyle Stadyum Yerlerinin Değerlendirmesi

Öz

Sporun endüstriyelleşmesinden sonra, stadyumlar sadece bir oyun alanı olmaktan çok daha fazlası haline gelmiştir. Buna göre, bir stadyum için en iyi yeri seçmek spor kulüpleri için önemli bir problemdir. Bu çalışmada, stadyum yeri alternatiflerini değerlendirmek için iki aşamalı bir Çok Kriterli Karar Verme modeli geliştirilmiştir. Birinci aşamada, kriter ağırlıklarının belirlenmesi için Analitik Hiyerarşi Süreci (AHS) kullanılmıştır. İkinci aşamada alternatifleri değerlendirmek için TOPSIS yöntemi kullanılmıştır. Alternatifleri değerlendirmek üzere dört ana kriter belirlenmiştir: (1) stadyumların kapasiteleri, (2) inşaat maliyetleri, (3) ulaşılabilirlik, (4) uzaklık. Önerilen model, İzmir'de yapılan üç yeni stadyum inşaatında vaka analizi ile sınanmıştır.

Anahtar Kelimeler: Çok Kriterli Karar Verme, Lojistik, Spor Kulüpleri, Analitik Hiyerarşi Süreci (AHS), TOPSIS

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Abstract

With the industrialization of sports, stadiums started to mean more than a venue for playing games. Therefore, choosing the best location for a stadium is an important problem for sports clubs. In this paper, a two-step hierarchical multi-criteria decision-making model has been developed to evaluate stadium locations. In the first step, Analytic Hierarchy Process (AHP) has been used to determine the criteria weights. In the second step, TOPSIS has been used to evaluate the alternatives. Four main criteria have been identified to evaluate alternatives: (1) stadium capacity, (2) construction cost, (3) accessibility and (4) distances. As a case study, the proposed model has been applied to three new stadium constructions in Izmir, Turkey.

Keywords: Multi-Criteria Decision Making, Logistics, Sports Clubs, Analytic Hierarchy Process (AHP), TOPSIS

1. Introduction

With the increased competition in the market, the importance of logistics has been increased to gain a competitive advantage. Also, sport is considered a new sector with the industrialization of sport and the expenses of sports clubs become enormous. Therefore, sports clubs need new ways to increase their income levels.

In the last decades, the logistics of sports clubs have gained more attention and stadiums are crucial parts of the logistics of the sports clubs. Until the 1990s, stadiums were only seen as the areas where sports events take place. Nowadays, stadiums mean much more than that. Supporters of the sports clubs see the stadiums as their home and sports clubs see stadiums as a new way to gain income by building new stadiums as entertainment centers. This makes stadiums more than only the areas that sports events take place. There are cafes, restaurants and even museums in the modern stadiums. Biggest sports clubs in the world use their stadiums as touristic places such as Nou Camp (Barcelona's stadium) and Allianz Arena (Bayern Munich's stadium). Stadiums are also attraction centers for the big companies and the sponsors of the clubs.

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All these reasons lead the sports clubs or governments to construct stadiums as "living places". To this end, the locations of the stadiums are crucial. As an analogy, if sports clubs are seen as companies, stadiums are distribution centers of these companies and a good location affects the performance of the company positively. However, choosing the location of the stadiums is a complex problem since it requires to be assessed for many criteria. This type of problem is considered as a multi-criteria decision making problem.

In this paper, we investigated a multi-criteria decision making problem that addresses choosing the best location for new stadiums to be built. To the best of the knowledge of the authors, this problem has not been investigated in the literature. Although many multi-criteria decision making methods have been applied in logistics, especially on choosing plant and warehouse locations, it is the first time that a multi-criteria decision making method is applied to sports clubs for their stadium location decisions. We proposed a two-step methodology using Analytic Hierarchy Process (AHP) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) to choose the best location for new stadiums. As a case study, we applied our proposed method to evaluate three new stadium construction projects in Izmir, Turkey.

This paper is organized as follows. In Section 2, the literature review about decision making in logistics and decision making in sports clubs are summarized. The problem is defined in Section 3. The methodology is explained in Section 4. Section 5 presents the results of the real-life case study which tests the proposed method. Conclusions and future work are given in Section 6.

2. Literature Review

The sports industry has relations with other sectors such as food, tourism, advertisement, health, entertainment, construction, and logistics sectors. The relation between logistics and sports clubs is a new research area. Logistics can be found in the sports industry such as sports event logistics and sports club logistics (Devecioğlu, 2005: 117). In this study, the sports club logistics topic is researched as thinking of a sports club as a company and stadiums belong to the sports club are the plants of the companies. Therefore, it is not an easy problem to determine or evaluate the location of a stadium.

In the last decades, sports have been improved as an industry. As a consequence, the number of research on sports has been increased, but several studies have been made about sports facilities. To the best of the authors' knowledge, there is no study about evaluating the location of the sports facilities such as stadiums. Subsidization of professional sports facilities was researched by Kellison & Mondello (2012: 500), Lasley & Turner (2010: 853), Coates & Humphreys (2016: 285), Thornley (2012: 813) and Sigfried & Zimbalist (2000: 95). Grieve & Sherry (2012: 218), Propheter (2012: 441), Coates (2006: 239), Gratton et al. (2006: 41), Sigfried & Zimbalist (2006: 420) investigated the economic impacts of the sports facilities. Seifried & Clopton (2013: 49), Ahlfeldt and Maennig (2010: 205), Barghchi et al. (2009: 185) and Yuen (2008: 29) have researched sports facilities as social anchors. Sustainable facility management is another aspect that was researched by Mallen & Chard (2012: 230), Koukiasa (2011: 217), Mallen et al. (2010: 367).

In the literature, decision making has always been a popular area for researchers. Decision making is the process of using decision making techniques to achieve specific goals by choosing the best alternative among a set of alternatives (Gwo-Hshiung and Huang, 2011: 1). Multi-Criteria Decision Making methods have been used in various topics such as airlines (Tsaur, Chang and Yen, 2007: 107), e-learning (Tzeng, Chiang, and Li, 2007: 1028), personnel selection (Liang and Wang, 1994: 22) and elevator control systems (Özcan, Karaköprü and Yap, 2017: 40).

AHP is extensively used in logistics literature. Some of the application areas are location selection for the logistics center (Karakaş et al., 2017: 607), logistics service provider selection (Falsini et al., 2012: 4822; Ecer, 2018: 615; Gürcan et al., 2016: 226), decision making of outsourcing logistics operations and decision making on reverse logistics (Bouzon et al., 2016: 182). AHP is also used in the area of sports. For example, AHP was used in football player selection (Ozceylan, 2016: 190-205), and sports sponsorship decision making (Lee and Ross, 2012: 156).

TOPSIS is one of the most common Multi-Criteria Decision Making methods and has been used widely in the logistics literature. Some of the application areas of TOPSIS in logistics literature are reverse logistics provider selection (Kannan, Pokharel and Kumar, 2009: 28), outsourcing logistics activities (Bottani and Rizzi, 2006: 294), evaluation of 3PL service providers (Percin, 2009: 588), and planning sustainable city logistics (Awasthi and Chauhan, 2012: 573).

As AHP and TOPSIS methods have been used widely, many literature review papers can also be found in the literature. To investigate the criteria that have been used in AHP literature, Russo and Camanho conducted a systematic literature review on the papers that AHP has been used (2015: 1123). To discover the areas of interest and trace the development of AHP research, Emrouznejad and Marra (2017: 6653) have reviewed the literature by analyzing 8,441 papers published between 1979 and 2017 that are based on the ISI Web of Science database. As TOPSIS have also been used widely in the literature, Behzadian, Otaghsara, Yazdani, and Ignatius (2012: 13051) have made a literature survey that includes 266 published papers from 103 journals since 2000 and seperated into nine application areas. Emrouznejad and Marra (2017) and Behzadian, Otaghsara, Yazdani and Ignatius (2012) indicated that various studies used AHP and TOPSIS to make logistics decisions, however, making logistics decisions of sports clubs using AHP and TOPSIS is a novel area. According to a recent literature review by Nisel and Özdemir (2016), the application of AHP methods are mainly on performance evaluation of teams or coaches, player selection and ranking, the ranking of teams, clubs or coaches.

In the last decades, as the importance of logistics for companies was understood, the number of studies in the logistics literature has been increased. In the logistics literature, Multi-Criteria Decision Making methods are mostly used for solving the problems such as green supplier selection (Büyüközkan and Çifçi, 2012: 3000), long-term supplier selection (Önüt, Kara and Işık, 2008: 3887), evaluation logistics service providers (Percin, 2009: 588) reverse logistics (Kannan, Pokharel and Kumar, 2009: 28) and facility location (Eruğrul and Karakaşoğlu, 2008: 783).

In sports literature, Multi-criteria Decision Making methods are used generally for selecting the players (Ballı and Korukoğlu, 2014: 56), privatization of sports clubs (Salimi, Soltanhosseini and Padash, 2012: 102), ranking sports teams (Sinuany-Stern, 1988: 661) or relation between sportive success and financial performances of sports clubs (Ergul, 2010: 69).

Facility location is a complex problem for the companies and if sports clubs are treated as companies, locating the stadium is an important decision making problem in which multiple criteria are involved. Using Multi-Criteria Decision Making methods for choosing stadium locations for sports clubs is a new topic in the literature that has not been studied in the literature. In this paper, a two-step Multi-Criteria Decision Making model is proposed. The proposed model first uses AHP to determine the criteria weights and then uses the TOPSIS method to evaluate the location alternatives in order to find the best stadium location for sports clubs.

3. Problem Definition

With the improvements and industrialization of sports, stadiums have changed from only the buildings that sports events take place to attraction centers. Also, stadiums are very important for sports clubs because gate receipts are crucial to increase income. An ideal stadium for a sports club should cost low, have a large capacity, be accessible for the spectators, be close to the club's own assets and be far from the rival clubs' assets.

Cost is the first criterion of our model, either the clubs are building their own stadiums or government builds their stadium to help clubs to save money. Cost includes construction cost or land cost. The capacity of the stadium is the second criterion. Gate receipts from the games are important cash in-flows for the sports clubs and larger capacities lead to a larger amount of money for the clubs. Being accessible is another criterion. The ideal stadium should be easily accessible by public transport to attract more spectators to the matches and therefore have more spectators. The headquarters and training grounds can be considered as the assets of the sports clubs. The stadium should be in the same area as the club's own assets because of gaining support from the people live in these areas. And its location should be far from the rival clubs' assets because people in that area don't feel themselves belong to the sports clubs and show less support. This can lead to a lower number of spectators in the matches and therefore, less income for the sports clubs.

4. Methodology

In this section, the methods used have been explained in detail.

4.1. Analytic Hierarchy Process

In this paper, AHP is used to determine the criteria weights and TOPSIS method is used to evaluate the alternatives. Analytic Hierarchy Process (Saaty, 1972: 28) is one of the most widely used Multi-Criteria Decision Making methods in the literature. AHP has been used in various areas such as sustainable and renewable energy (Singh and Nachtnebel, 2016: 43), agriculture (Abdollahzadeh et al., 2016: 27), health (Nguyen and Nahavandi, 2016: 273), and nuclear power (Erdoğan and Kaya, 2016: 84).

Analytic Hierarchy Process is explained step by step as follows:

Step 1: The pairwise comparison matrix for each criterion is determined by comparing each option with each other. This matrix size is being shown as $\times n$. When pairs are being compared linear scale is being used which can be seen in Table 1. The pairwise comparison matrix can be seen as:

$$A = \begin{bmatrix} a_{11} \; a_{12} \dots \; a_{1n} \\ a_{21} \; a_{22} \dots a_{2n} \\ \dots \; \dots \; \dots \; \dots \\ a_{n1} \; a_{n2} \dots a_{nn} \end{bmatrix}$$

Because of the linear comparison, $a_{ij} = \frac{1}{a_{ji}}$. For example, if *a* is 7 times more important than *b*, which means that alternative *a* has very strong importance over alternative *b*, then, *b* is 1/7 times important than *a*.

Table 1: Linear Scale of AHP (Saaty, 1972)

Intensity of Importance	Definition	Explanation
1	Equally strong	Two activities contribute equally to the objective
3	Marginally strong	Experience and judgment strongly favor one activity over another
5	Strong	Experience and judgement strongly favor one activity over another
7	Very strong	Activity is strongly favored and its dominance demonstrated in practice
9	Extremely strong	The evidence favoring one activity over another is of tile highest possible order of affirmation
2,4,6,8	Intermediate Values	When compromise is needed

Step 2: Factors' weights are being determined in this step. To determine the weights, column vectors of the pairwise comparison matrix are being used. In the end, n numbered *B* column vector is being determined. Column vector *B* has n number of components. This *B* column vector can be seen as:

$$B_i = \begin{bmatrix} b_{11} \\ b_{12} \\ b_{13} \\ \dots \\ b_{1n} \end{bmatrix}$$

The formula to calculate the column vectors can be written as:

$$b_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}$$

After n number of *B* columns are obtained, these columns are constructed for C matrix.

$$C = \begin{bmatrix} c_{11} & c_{12} & c_{13} & \dots & c_{1n} \\ c_{21} & c_{22} & c_{23} & \dots & c_{2n} \\ c_{31} & c_{31} & c_{33} & \dots & c_{3n} \\ \dots & \dots & \dots & \dots & \dots \\ c_{n1} & c_{n2} & c_{n3} & \dots & c_{nn} \end{bmatrix}$$

Where;

$$c_{11} = b_{11}$$
$$c_{n1} = b_{n1}$$
$$c_{1n} = b_{1n}$$
$$c_{nn} = b_{nn}$$

To determine weights, w column vector, the arithmetic average of the values of lines of *C* matrix, is determined as the following formula:

$$w_i = \frac{\sum_{j=1}^{n} c_{ij}}{n}$$

Weights vector is determined by using the obtained w values.

$$W = \begin{bmatrix} w_1 \\ w_2 \\ w_3 \\ \dots \\ w_n \end{bmatrix}$$

Step 3: Consistency Ratio is calculated in this step. Analytic Hierarchy Process is based on the comparison of the decision maker and to apply the method successfully, comparisons should be consistent. The consistency ratio is based on the comparison between the number of factors and a coefficient called basic value which is shown as λ. To calculate the λ, *D* vector column should be calculated by multiplying the A comparison matrix and *W* weights vector. It can be formulated as:

$$D = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ \dots & \dots & \dots & \dots \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{bmatrix} \times \begin{bmatrix} w_1 \\ w_2 \\ w_3 \\ \dots \\ w_n \end{bmatrix}$$

Then, by using the *D* vector column, *E* values are first determined with the formula:

$$E_i = \frac{d_i}{w_i}$$

After that, the arithmetic average of the *E* values gives the value of λ and can be formulated as:

$$\lambda = \frac{\sum_{i=1}^{n} E_i}{n}$$

After λ is calculated, Consistency Indicator (*CI*) can be calculated by the formula:

$$CI = \frac{\lambda - \mathrm{n}}{n - 1}$$

Then, the Consistency Ratio (*CR*) is calculated by dividing the Consistency Indicator (*CI*) to its corresponding Random Indicator (*RI*). Random Indicator values are already determined and can be seen in Table 2.

Table 2: Random Indicator Values (Saaty R. W., 1987)

Number of *n*	**RI**
1	0
2	0
3	0.58
4	0.90
5	1.12
6	1.24
7	1.32
8	1.41
9	1.45
10	1.49
11	1.51

Consistency Ratio should be less than or equal to 0.10 to achieve a meaningful and consistent result, otherwise, it means that the comparisons are inconsistent and all the calculations are invalid.

Step 4: By applying the same steps for each factor to the options, the standardized decision matrix is calculated. A standardized decision matrix can be seen as *K* matrix where s_{ij} represents the standardized value of decision point:

$$K = \begin{bmatrix} s_{11} & s_{12} & s_{13} & \dots & s_{1n} \\ s_{21} & s_{22} & s_{23} & \dots & s_{2n} \\ \dots & \dots & \dots & \dots & \dots \\ s_{m1} & s_{m2} & s_{m3} & \dots & s_{mn} \end{bmatrix}$$

Step 5: Multiplying *K* matrix with *W* weights column vector, *L* column vector is constructed. Column vector *L* represents the scores of the options and can be formulated as:

$$L = \begin{bmatrix} s_{11} & s_{12} & s_{13} & \dots & s_{1n} \\ s_{21} & s_{22} & s_{23} & \dots & s_{2n} \\ \dots & \dots & \dots & \dots & \dots \\ s_{m1} & s_{m2} & s_{m3} & \dots & s_{mn} \end{bmatrix} \times \begin{bmatrix} w_1 \\ w_2 \\ w_3 \\ \dots \\ w_n \end{bmatrix} = \begin{bmatrix} w_1 s_{11} + w_2 s_{12} + w_3 s_{13} + \dots + w_n s_{1n} \\ w_1 s_{21} + w_2 s_{22} + w_3 s_{23} + \dots + w_n s_{2n} \\ \dots \\ w_1 s_{m1} + w_2 s_{m2} + w_3 s_{m3} + \dots + w_n s_{mn} \end{bmatrix}$$

The best alternative to choose is the alternative with the highest overall score.

4.2. TOPSIS

TOPSIS method has been introduced by Chen and Hwang (1992: 289). TOPSIS method's main aim is to find the best alternative that has the shortest distance from the positive ideal solution while having the furthest distance from the negative ideal solution (Zeleny, 1998: 97).

TOPSIS has been explained in detail as follows:

Step 1: In the first step, the decision matrix has been constructed which is shown as (D).

$$D = \begin{bmatrix} y_{11} & y_{12} & \dots & y_{1n} \\ y_{21} & y_{22} & \dots & y_{2n} \\ \dots & \dots & \dots & \dots \\ y_{n1} & y_{n2} & \dots & y_{nn} \end{bmatrix}$$

Step 2: Decision matrix *D* is standardized with the following formula:

$$r_{ij} = \frac{y_{ij}}{\sqrt{\sum_{i=1}^{n} y_{ij}^2}}$$

Upon completing the calculations, the standardized decision matrix *R* is determined as:

$$R = \begin{bmatrix} r_{11} & r_{12} & \dots & r_{1n} \\ r_{21} & r_{22} & \dots & r_{2n} \\ \dots & \dots & \dots & \dots \\ r_{n1} & r_{n2} & \dots & r_{nn} \end{bmatrix}$$

Step 3: Next, the weighted standardized decision matrix *W* is calculated. In *W*, w_j is the weight of criterion *j*, weights are determined as:

$$W = \begin{bmatrix} w_{11} & w_{12} & \dots & w_{1n} \\ w_{21} & w_{22} & \dots & w_{2n} \\ \dots & \dots & \dots & \dots \\ w_{n1} & w_{n2} & \dots & w_{nn} \end{bmatrix}$$

Then, *R* matrix is multiplied by *W* matrix to calculate the weigted standardized decision matrix which is shown as *V*.

$$V = \begin{bmatrix} v_{11} & v_{12} & \dots & v_{1n} \\ v_{21} & v_{22} & \dots & v_{2n} \\ \dots & \dots & \dots & \dots \\ v_{n1} & v_{n2} & \dots & v_{nn} \end{bmatrix}$$

Step 4: After that, positive ideal and negative ideal solutions are determined. The positive ideal solution can be formed as:

$$A^+ = (v_1^+, v_2^+, \dots, v_n^+) = \left(\left(max v_{ij} \middle| j \in I \right), \left(min v_{ij} \middle| j \in J \right) \right)$$

The negative ideal solution can be formed as:

$$A^{-} = (v_1^{-}, v_2^{-}, \dots, v_n^{-}) = \left(\left(minv_{ij} \middle| j \in I\right), \left(maxv_{ij} \middle| j \in J\right) \right)$$

Where I is associated with benefit and J is associated with cost criteria.

<u>Step 5:</u> Then, the distances from the positive ideal solution and the negative ideal solution are calculated. The distance of alternative *i* from the positive ideal solution is given as:

$$d_i^{+} = \left(\sum_{j=1}^{n} \left(v_{ij} - v_j^{+}\right)^p \right)^{1/p} , i = 1,2, \dots, m$$

The distance of alternative *i* from the negative ideal solution is calculated as:

$$d_i^{-} = \left(\sum_{j=1}^{n} \left(v_{ij} - v_j^{-}\right)^p \right)^{1/p} , i = 1,2, \dots, m$$

<u>Step 6:</u> The relative closeness to the positive ideal solution is calculated. The relative closeness of the i-th alternative A_{j} with respect to $A^{+}$is defined as:

$$R_{\mathrm{i}} = \frac{d_i^{-}}{d_i^{-} + d_i^{+}}$$

Where $0 \leq R \leq 1$, $i = 1,2, \dots, m$.

<u>Step 7</u>: In the last step, alternatives are ordered according to their R_{i} values, where a higher score indicates a better alternative.

5. Case Study and Results

In the case study, three new stadiums that are being built in Izmir, Turkey are evaluated. These stadium buildings are in Goztepe, Karsiyaka and Alsancak areas, are being built for sports clubs Goztepe, Karsiyaka, and Altay, respectively. The proposed model has been applied to evaluate the locations of these stadiums.

In our study, stadium locations are evaluated according to these criteria and the hierarchy of the model is depicted in Figure 1.

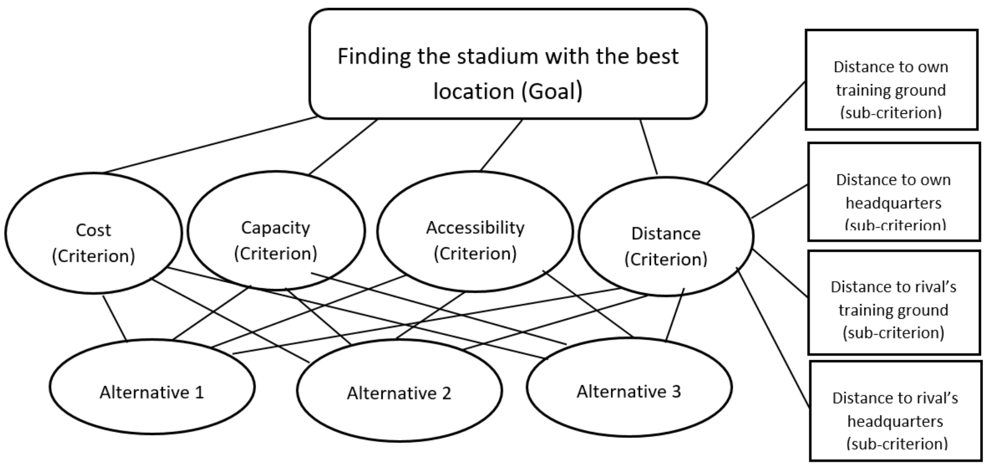

Figure 1: Problem Hierarchy

Criteria weights are first determined by using AHP on an MS Excel template which is developed by Klaus D. Goepel (taken from http://bpsmg.com). The decision maker in this problem is assumed to be a government official since the stadiums are being built by the state. In this case, each criterion has been compared with the other criteria according to the Linear Scale of AHP (given in Table 1). Linear Scale is used to compare the criteria with each other according to their importance.

To calculate the scores of the alternatives, sub-criteria scores of distance criterion must be first evaluated. Note that distance criterion has four sub-criteria as explained in Figure 1. Pairwise comparisons of the sub-criteria of distance criterion are shown in Table 3.

Table 3: Pairwise Comparison of Sub-Criteria of Distance Criterion

	Distance to Own Training Ground	**Distance to Own Headquarters**	**Distance to Rival Training Ground**	**Distance to Rival Headquarters**
Distance to Own Training Ground	1	5	3	2
Distance to Own Headquarters	1/5	1	1/3	1/5
Distance to Rival Training Ground	1/3	3	1	1/2
Distance to Rival Headquarters	1/2	5	2	1

Then, these values are summed for each criterion and each cell values in the column are divided by this summation. For example, the total of the column “distance to own training ground and stadium” sub-criterion: 1+1/5+1/3+1/2=2.033. Then, each cell in this column is normalized as 1/2.033=0.49, 0.20/2.033=0.10, 0.33/2.033=0.16, 0.5/2.033=0.25. The result gives the standardized decision matrix as shown in Table 4.

Table 4: Standardized Decision Matrix of Sub-Criteria of Distance

Distance to Own Training Ground	**Distance to Own Headquarters**	**Distance to Rival Training Ground**	**Distance to Rival Headquarters**
0.49	0.36	0.47	0.54
0.10	0.07	0.05	0.05
0.16	0.21	0.16	0.14
0.25	0.36	0.32	0.22

Then, all values are summed for each column to calculate the totals of the rows. For example, the row total of “distance to own training ground and stadium” sub-criterion is: 0.49+0.36+0.47+0.54=1.86. Then, each row total is divided by four to calculate the weight of each criterion. For example, the cost weight is calculated by 1.86/4=0.469. Lastly, the consistency ratio of the pairwise comparisons is checked. The consistency ratio is 2.2%, which is acceptable as it is less than 10%. The calculated criteria weights are given in Table 5.

Table 5: Sub-Criteria Weights of Distance

Sub-Criteria	**Weight**
Distance to Own Training Ground	0.47
Distance to Own Headquarters	0.07
Distance to Rival Training Ground	0.17
Distance to Rival Headquarters	0.30

Then, scores of the alternatives for the distance criterion are calculated. Distances are obtained from Google Maps (www.maps.google.com). Each distance is multiplied by the weight and summed up to obtain the distance score for each alternative. For example, Goztepe Stadium's distance values are determined as: "distance to own training ground" is 39 km, "distance to own headquarters" is 0.55 km, "distance to rival training ground" is the distance value between the stadium and nearest rival clubs' training ground which is 13.7 km and "distance to rival headquarters" is the distance between the stadium and nearest rival clubs' headquarters which is 13.7 km. The values of "Distance to own training ground" sub-criterion and "Distance to own headquarters" sub-criterion are being divided by one because the closer is better, other sub-criteria values are used directly because far is better. All distance values can be seen in Table 6.

Table 6: Distance Values of the Alternatives

Distances from/to	Own Training Ground	Own Headquarters	Rival Training Ground	Rival Headquarters
Goztepe Stadium	1/39	1/0.55	13.7	13.7
Karsiyaka Stadium	1/8.2	1/5	26	18.9
Alsancak Stadium	1/16.4	1/16.4	17.6	10.9

After that, distance values are obtained, each value is divided by the sum of square root values of each sub-criterion to standardize each sub-criterion scores. As an example, Goztepe Stadium distance to own training ground value is standardized as $\frac{(1/39)}{(1/39)^2+(1/8.2)^2+(1/16.4)^2} = 0.185$. All standardized values can be seen in Table 7.

Table 7: Standardized Distance Values

Distances from/to	Own Training Ground	Own Headquarters	Rival Training Ground	Rival Headquarters
Goztepe Stadium	0.185	0.993	0.400	0.532
Karsiyaka Stadium	0.879	0.109	0.759	0.734
Alsancak Stadium	0.440	0.033	0.514	0.423

Next, distance scores of every alternative are calculated by the sum of the multiplying standardized values by the corresponding sub-criterion weight. As an example Goztepe Stadium distance criterion stadium is calculated as: (0.185×0.47) + (0.993×0.47) + (0.4×0.17) + (0.532×0.30) = 0.384. Distance criterion scores can be seen in Table 8.

Table 8: Distance Criterion Scores

Alternatives	Distance Scores
Goztepe Stadium	0.384
Karsiyaka Stadium	0.770
Alsancak Stadium	0.423

After that, with similar calculations, criteria weights are determined. Criteria weights can be seen in Table 9. The consistency ratio is calculated as 4.8% and comparisons are acceptable as it is lower than 10%.

Table 9: Criteria Weights

Criteria	Weight
Capacity	0.26
Building Cost	0.52
Accessibility	0.14
Distance	0.09

Then, the decision matrix is constructed. Capacity and cost data are taken from the publicly available news websites from the internet. Cost values are being divided by one because the lower is better for the cost criterion. Distance scores are calculated in the previous step. Accessibility scores are calculated by the data from the ESHOT (Electric, Water, Airgas, Bus and Trolleybus), official public transportation of the Izmir city (http://www.eshot.gov.tr). Each public transport line that has a public transport stop within a 100 m radius of the stadium increases accessibility score by one point. The decision matrix is given in Table 10.

Table 10: Decision Matrix

Alternatives	Capacity	Cost	Accessibility	Distance
Goztepe Stadium	20,035	$\frac{1}{218{,}900{,}000}$	9	0.384
Karsiyaka Stadium	15,000	$\frac{1}{62{,}000{,}000}$	23	0.77
Alsancak Stadium	14,000	$\frac{1}{54{,}880{,}000}$	15	0.423

The next step is to obtain the standardized decision matrix. Each value is divided by the square root of the sum of the values for each criterion. For example, Goztepe Stadium's standardized cost value is calculated as: $\frac{\frac{1}{218{,}900{,}000}}{\sqrt{(\frac{1}{218{,}900{,}000})^2+(\frac{1}{62{,}000{,}000})^2+(\frac{1}{54{,}880{,}000})^2}} = 0.184$. The standardized decision matrix is obtained as in Table 11.

Table 11: Standardized Decision Matrix

Alternatives	Capacity	Cost	Accessibility	Distance
Goztepe Stadium	0.699	0.184	0.311	0.401
Karsiyaka Stadium	0.523	0.651	0.796	0.803
Alsancak Stadium	0.488	0.736	0.519	0.441

Then, each value is multiplied by its correspondent criterion weight to calculate the weighted standardized decision matrix. For example, Goztepe Stadium's weighted standardized capacity value is calculated as 0.699×0.26=0.182. The weighted standardized decision matrix is constructed as in Table 12.

Table 12: Weighted Standardized Decision Matrix

Alternatives	Capacity	Cost	Accessibility	Distance
Goztepe Stadium	0.182	0.096	0.044	0.036
Karsiyaka Stadium	0.136	0.338	0.111	0.072
Alsancak Stadium	0.127	0.383	0.073	0.441

Next, positive ideal solution values and negative ideal solution values are determined. The ideal positive solution is the solution that maximizes the benefit criteria (or minimizes the cost criteria) whereas the negative ideal solution maximizes the cost criteria (or minimizes the benefit criteria). The ideal solution values can be seen in Table 13.

Then, the distances from the ideal solutions are calculated. To calculate the positive ideal distance values of each alternative, the sum of the square of the differences between each weighted standardized value and positive ideal solution value is calculated. All positive ideal distance values are shown in Table 14. As an example, Goztepe Stadium's positive ideal distance value is calculated as $\sqrt{(0.182-0.182)^2+\cdots+(0.043-0.072)^2} = 0.295$.

Table 13: Ideal Solution Values

Ideal Solution Values	Capacity	Cost	Accessibility	Distance
Positive Ideal Solution Values	0.182	0.383	0.111	0.072
Negative Ideal Solution Values	0.127	0.096	0.044	0.036

Table 14: Positive Ideal Distance Values

Alternatives	Positive Ideal Distance Values
Goztepe Stadium	0.297
Karsiyaka Stadium	0.064
Alsancak Stadium	0.075

Similarly, the negative ideal distance values are calculated (Table 15). To calculate the negative ideal distance values of each alternative, the sum of the square of the differences between each weighted standardized value and negative ideal solution value is calculated. All negative ideal distance values are shown in Table 14. As an example, Goztepe Stadium's negative ideal distance value is calculated as $\sqrt{(0.182-0.127)^2+\cdots+(0.043-0.036)^2}=0.055.$

Table 15: Negative Ideal Distance Values

Alternatives	Negative Ideal Distance Values
Goztepe Stadium	0.055
Karsiyaka Stadium	0.255
Alsancak Stadium	0.289

Finally, the relative closeness of each alternative to the positive ideal solution is calculated. To obtain these values, the negative ideal distance value is divided by the sum of the positive ideal distance value and negative ideal distance value for each alternative. For example, Goztepe Stadium's relative closeness is calculated as 0.055/(0.055+0.297)=0.155. All relative closeness values of alternatives are given in Table 16.

Table 16: Relative Closeness Values

Alternatives	Relative Closeness Values
Goztepe Stadium	0.155
Karsiyaka Stadium	0.800
Alsancak Stadium	0.795

It can be seen that Karsiyaka Stadium has the best location. However, Alsancak Stadium is almost as good as Karsiyaka Stadium. The worst location is Goztepe Stadium.

6. Conclusions

In the last decades, the number of decision making problems in logistics has increased. However, logistics management in sports clubs is quite a new issue. The importance of stadium locations of sports clubs has increased in parallel with the increasing industrialization and professionalization levels of sports. On the other hand, there are only a few studies about decision making in sports clubs, and there is no study addressing stadium location problem for sports clubs.

With the industrialization of the sports, expenses in sports club have been raised. Therefore, sports clubs that want to be successful, need new income saves. Stadiums have been an important way of income, as they started to be seen as entertainment centers. In some stadiums, there are cafes, restaurants, and a sports club's museum. Some stadiums are even being used for cultural events such as concerts, these events and gate receipts for the matches give a massive boost to the sports club's budgets. Therefore, it is crucial that the stadiums are built in good locations. To find a good location, decision makers in sports clubs and governments face a complex multi-criteria problem.

To solve this problem, a two-step methodology is proposed in this study. It is basically a decision support system for the decision makers to use Multi-Criteria Decision Making methods. In the first step of the method, AHP is used to determine the criteria weights. In the second step, TOPSIS is used to make the decision on finding the best stadium location for the clubs. To the best of our knowledge, Multi-Criteria Decision Making methods have not been used to choose stadium locations.

In this paper, a real-life case study has been presented to test the proposed method. Three new stadium constructions in Izmir, Turkey. The real data are taken from online sources and the alternatives are evaluated. The alternatives of this real-life case study are Goztepe Stadium for Goztepe, Karsiyaka Stadium for Karsiyaka and Alsancak Stadium for Altay sports clubs. Criteria are determined as the capacity of the stadium, the cost of the construction, the accessibility of the stadium by public transport and the distances from the assets. The distances from the other assets criterion has four sub-criteria: (1) distance to the stadium and club's training ground, (2) distance to the stadium and club's headquarters, (3) distance to the stadium and rival clubs' training grounds and (4) distance to the stadium and rival clubs' headquarters.

The case study showed that Karsiyaka Stadium has the best location. The second best location is Alsancak Stadium which has a very close score to Karsiyaka Stadium. The worst location is Goztepe Stadium even though Goztepe Stadium has the largest capacity. This method can also be used before construction starting and it can help to choose the best stadium location.

For future work, this study will be extended to include more criteria and decision makers. Also, fuzzy multi-criteria decision making can be used. This study can be extended with the perspectives of supporters of sports clubs or other stakeholders.

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