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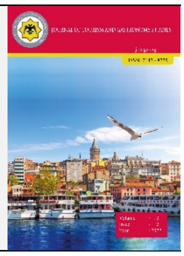

An Integrated Fuzzy TOPSIS and Best-Worst Methodology for a Sinkhole Selection as a Geotourism Destination

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Abstract

Sinkholes are important formations for the tourism sector with their natural beauties and structures that scare people but make them want to see. The study aims to determine which of the sinkholes has the highest criteria for being a tourism destination, by weighting the criteria of being a tourism destination for the sinkholes according to their importance. In this way, it is aimed to contribute to directing the investments to be made through the sinkholes as a geotourism center to the right sinkhole. The criteria that a place should have to be a tourism destination have been ranked by the experts according to their importance with the Best-Worst Method (BWM). Thus, determine the weighting coefficients of the criteria. Then, expert opinions were taken for four different sinkholes and the FUZZY TOPSIS method, which facilitates decision making in blurred environments, was used. The most suitable sinkhole was chosen for the visitors.

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INTRODUCTION

People can go on touristic trips with a wide variety of motivations. Many cities have similar attractions (Hede & Hall, 2006), but different types of people have different reasons to visit them. These motivations include the pursuit of knowledge and adventure, natural attractions, socio-cultural activities, seeking change, transportation and activity opportunities, individual factors, experiencing different things, feeling excitement, discovering new places, price, historical and natural beauties, image, quality, shopping opportunities, security, boasting, climate, population density, etc. elements exist (Ekici & Özcan, 2000; Mutinda & Mayaka, 2012; Zhang & Peng, 2014; Ustasüleyman & Çelik, 2015; Tulga vd.,2016; Davras & Uslu, 2019; Uğur & Uğur, 2019). Cultural value perceptions are also one of the factors affecting the destination selection image (Mercan & Kazancı, 2019). These factors shape the competitiveness of destinations. Variables such as culture and heritage, infrastructure, communication opportunities, price competitiveness, social competitiveness, education, environmental protection also explain the competitiveness of destinations. (Mazanec et al., 2007) The sinkholes covered in the study are among the natural attractions that can be a source of geotourism with their formation, different structures and intriguing appearances. As the attractiveness of destinations and the types of services they offer to increase and differentiate, they will have the advantage of competing with other destinations.

Conical and cylindrical karst features of various depths and diameters occurring between Karapınar and Kizoren are defined as 'Obruk type karstification'. The most important factors in sinkhole type karstification are the lithology of the rocks, the effects of neotectonism in the region, the flow direction and chemical composition of the groundwater (Canik & Çörekçioğlu, 1985). Konya Province and its surroundings have been the scene of sinkhole formations for a long time, with the effect of its geological structure, underground waters and tectonism. Recently, there has been an increase in the number of sinkholes in Konya, located in Central Anatolia. In the increase of the number of sinkholes; In addition to the arid and semi-arid climatic conditions in the field, a combination of natural and human factors such as agricultural patterns, the drilling of many deep wells, and increased water pumping are observed (Doğan & Yılmaz: 2011; Tapur & Bozyiğit, 2015). Although it is known that sinkholes have been formed thousands of years ago, their numbers have been increasing in recent years. Especially after the 2000s, the formation of sinkholes has increased and awareness has been raised on this issue. In this context, as a result of various researches carried out in the region, 299 sinkholes were detected as of the end of 2017, while 19 sinkholes were identified in 2018 and nearly 30 new sinkholes were formed in 2019 (www.ktun.edu.tr). This increase in the number of sinkholes has led to an increase in the interest in sinkholes. However, although the increase in the number of sinkholes has increased the potential for geotourism, this actually shows that the groundwater in Konya has decreased in the same parallel, and in fact, the city has been slowly falling into a sinkhole disaster.

In the areas where the sinkholes of Konya province are located, there are alternative tourism values rich in terms of volcanic forms, natural lakes, caves, religious structures, traditional plateau settlements, historical mounds, historical settlements and other human elements. All these are resources that can help the development of tourism in the region (Tapur & Bozyiğit, 2016). Konya, which currently hosts thousands of cultural and religious tourism visitors every year, is thought to be a geotourism destination with its geological features.

The subject of the study is to analyze the motivations of visitors to visit the sinkholes in the Konya region as a geotourism destination. The study aims to determine which of the Kızören, Meyil, Çıralı, Timraş sinkholes in Konya has the highest criteria for being a tourism destination by weighting the criteria of being a tourism destination according to their importance. Therefore, it is hoped that all kinds of investments made by the public and private sectors will contribute to the most suitable destinations as a result of correct planning. In this context, first of all, the criteria that a place must meet to be a touristic destination, the motivations of the visitors and the literature review about the sinkholes were made. Then, the four most well-known sinkholes of Konya were discussed and the criteria that a place should meet to be a tourism destination were ranked according to the degree of importance by the experts with the Best-Worst method. Finally, the most suitable sinkhole for visitors to travel to was selected with the Fuzzy TOPSIS method by taking expert opinions for the four sinkholes. The rest of the paper is organized as follows: Section 2 presents; Touristic Destinations, Konya Province Sinkholes as a Tourism Destination, Best-Worst Method (BMW) and Technique for Order Preference by Similarity to Ideal Solution (FUZZY TOPSIS) Method.

Literature

A tourism destination is a complex structure that attracts tourists with its tourism resources and consists of direct and indirect tourism services offered by many institutions and organizations (Özdemir, 2014). Behavioral intentions and preferences of tourists towards tourism activities and destinations should be closely followed (Çelik et al., 2019). In this way, destinations will be able to compete with their competitors, and they will have the opportunity to gain a competitive advantage by revealing their superiority.

Some factors include many features such as economic, cultural, psychological and demographic in the choice of destination of tourists. For this reason, it is important to know which factors affect people's holiday preferences. Businesses can both expand their market and attract more customers by investing in the factors that affect consumers or by making improvements in that field (Ekici & Özcan, 2020). Individuals participating in tourism activities, while choosing the destination where they will spend their holidays, depend on the natural resources of that place, tangible or intangible cultural heritage assets, infrastructure and superstructure opportunities, the relations between the stakeholders in the tourism sector directly or indirectly in the region, and the quality of the services provided. They give importance to various factors such as at different levels (İpar & Doğan, 2013).

There are many studies examining tourists' travel motivations and destination choices. Some of those; Huang & Hsu (2009), Jang et al. (2009), Khan et al. (2017), Mutanga et al. (2017), Houdement et al. (2017), Khan et al. (2019), Wijaya et al. (2019), Su et al. (2020), Mandasari (2021). Sangpikul (2007) found travel arrangements and facilities, historical and cultural attractions, shopping and leisure activities and safety and cleanliness as attractive factors. In addition, the search for knowledge and novelty and historical and cultural attractions have also been recognized as important push and pull factors (Sangpikul, 2007). Thosuwonchinda et al. (2021) used the Travel and Tourism Competitiveness Index as relevant factors affecting the choice of travel destinations. These factors are tourist attractions, atmosphere, tourist infrastructure, recreation areas, organization and management, public facilities, social environment, accessibility, hospitality, economy and politics (Thosuwonchinda et al., 2021). Destinations are the places that make up the supply side of tourism activities that offer various attractions, transportation places and different types of accommodation, dining, sales and supporting services. Destinations offer very different services in the tourism market where competition is very intense. For this reason, it becomes very difficult to choose between destinations (Cavlak & Cop, 2018). When the relevant literature is scanned, very few studies have been found on the selection of sinkholes as a tourism destination. For this reason, this study is considered to be important.

Konya Province Sinkholes as a Tourism Destination

Today's new tourists want to experience alternative tourism types. They may want to explore different destinations, experience loneliness, taste flavors they have not tried before, get to know different cultures, and spend more time in the natural environment. In this sense, sinkholes can be considered as an alternative for tourists. Because sinkholes are formations that cannot be seen frequently with the way they occur. It is possible to come across many sinkholes that attract attention with their appearance in Konya.

It is noteworthy that the incidence of sinkhole formation has increased in recent years. It is thought that the excessive use of groundwater by people is effective in increasing this frequency. The rapid decrease in groundwater level over the last 30 years; It can be understood from Çıralı, Timraş, Akgöl, Meke Lake, Acıgöl, Kızören sinkhole lakes. During the underground water flow from Konya Plain to Salt Lake, the underground waters dissolve the karst rocks with which they are in contact and underground cavities are formed. These cavities collapse as a result of both underground waters and the wrong land use by people, and karstic formations called sinkholes to emerge. New sinkhole formations are also expected if the current land and groundwater use is continued (Tapur & Bozyiğit, 2015). Within the scope of the study, Kızören, Meyil, Çıralı and Timraş sinkholes, which are thought to be more prone to tourism, were evaluated by evaluating expert opinions.

The necessary tourism infrastructure should be prepared and promoted for the use of sinkholes in the field of tourism. Local people should be made aware and educated about tourism. Thus, sinkholes, which are an important natural resource, are protected and contribute to the economic development of the local people. For this reason, these areas should be turned into geoparks to be used in the field of tourism, rather than people being afraid of the sinkholes that have formed and continue to form in the region. In 2012, UNESCO Turkey National Commission decided to submit the sinkhole plateau to the Temporary List of UNESCO World Heritage-Turkey Natural Areas with second-degree priority (Tapur & Bozyiğit, 2016).

Most of the sinkholes can be easily accessed by anyone with their car. Ken and Meyil sinkholes, together with their lakes, can be said to be on the tourist route with “Meke volcanic crater lake”. Most of the large old sinkholes are close to the well gravel road that runs from Kızoren to Karapınar over the plateau Akörenkışla and Esentepe (Waltham, 2015). The roads around the Obruk are mostly irregular plateau roads connecting the plateau settlements in the region and to the permanent settlements. The important problem is the risk of collapse due to the expansion of the sinkhole slopes. If the subject is approached with the understanding of sustainable tourism, the sinkholes should be accepted as natural protected areas, therefore, attention should be paid to the lithological and ecological structure (Tapur & Bozyiğit, 2016). Existing sinkholes should be evaluated, and some precautions should be taken for new sinkholes. These measures should both ensure the safety of life and property and protect the regional structure. For example, deep wells should be closed and crop production that is not suitable for the climate should be stopped. Overuse should be prevented by controlling the water pressure. Studies should be carried out for underground determinations. (Doğan & Yılmaz, 2011).

Method

Best-Worst Method (BWM)

Decision-making is an activity that a person has to do throughout his life. As well as personal activities, institutions and organizations have to make this application in multi-criteria and multi-alternative decision processes in their work. As the criteria increased, mathematical analyzes were needed as well as intuitive expressions. Strategic decision-making can be made with mathematical and rational analysis. Multi-criteria decision-making emerged as a result of this need and presented methods that provide analytical results (Saaty, 2005).

BWM, introduced by Rezaei (2015), has been used frequently in recent years because it reduces the number of pairwise comparisons. BWM provides pairwise comparison resulting in reliable and highly consistent results and uses just two vectors instead of a complete pairwise comparison matrix (Yucesan et al., 2019). Rezaei (2015) lists the BMW process steps as follows:

"Step 1: A set of decision criteria needs to be determined. In this step, the decision-maker decides the n criteria $(C_1, C_2, \dots, C_n)$ *used to make the decision.*

Step 2: The best (most desirable, most significant) and worst (least desirable, least significant) criteria are determined.

Step 3: It is the stage where the best criteria was chosen determines the preference rate according to all other criteria by using a number between 1 and 9. Using a number between 1 and 9, the best criterion is chosen over all other criteria. As a result of this step, a vector called Best-Others (AB) is reached, which progresses from the best to the others. This vector should look like this:

$$A_B = (a_{B1}, a_{B2}, \dots, a_{Bn})$$

Each a_{Bj}*, in vector AB represents the preference of best criterion B over criterion j. Also,* a_{BB}*= 1. This means that the most important criterion will be compared against itself.*

Step 4: Using a number between 1 and 9, it is about determining the ratio of preference of all other criteria over the worst preferred criterion. In this step, the relative importance of the other criteria over the worst criterion is determined by the decision-maker using a number from 1 to 9. As a result of this step, the worst vector should be:

$$A_w = (a_{1W}, a_{2W}, \dots, a_{nW})^T$$

In this vector, each a_{JW} *indicates criterion j's preference over the worst criterion W, and* a_{WW} *= 1. This means that the worst criterion will be compared with itself.*

*Step 5: In the last step, it is necessary to determine the most appropriate weight for each criterion (w1 *, w2*, ……… wn*).*

In this step, the aim is to determine the optimal weights of the criteria to provide maximum absolute differences.

The optimal weight for the criteria is $\frac{w_B}{w_j}= a_{Bj}$ *and* $\frac{w_J}{w_W}= a_{jW}$ *for each* $(w_1^*, w_2^*, \dots, w_n^*)$ *pair, respectively. There must be values of j,* $\left|\frac{w_B}{w_j} - a_{Bj}\right|$, $\left|\frac{w_j}{w_W} - a_{jW}\right|$ *where the maximum absolute differences are minimized, which is translated into the following min –min-max:*

$$\min \max_j \left\{\left|\frac{w_B}{w_j} - a_{Bj}\right|, \left|\frac{w_j}{w_W} - a_{jW}\right|\right\} \quad (1)$$

subject to

$w_j \geq 0, for\ all\ j$ *(2)*

$\sum_{j=1}^{n} w_j = 1$ *(3)*

This mathematical model can be represented:

$min\ \zeta$ *(4)*

subject to:

$\left|\frac{w_B}{w_j} - a_{Bj}\right| \leq \zeta, for\ all\ j$ *(5)*

$\left|\frac{w_j}{w_W} - a_{jW}\right| \leq \zeta,\ for\ all\ j$ *(6)"*

FUZZY TOPSIS Method

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) is one of the Multi-Criteria Decision Making (MCDM) methods. It was developed by Hwang and Yoon (1981) (Chen, 2000). The TOPSIS method takes into account both the distance from the positive ideal solution and the distance from the negative ideal solution while finding the necessary proximity to the ideal solution. By comparing these distances, the preference order is made (Janko & Bernroider, 2005). TOPSIS is one of the most preferred multi-criteria decision-making methods (Martin et al., 2019).

With the fuzzy TOPSIS method, evaluation can be made by considering both qualitative and quantitative criteria. Fuzzy TOPSIS has a very flexible structure (Chen et al., 2005). Fuzzy TOPSIS method is very suitable for solving problems that require group decision-making in situations where the decisions of decision-makers vary. The importance weights and criteria values of the different criteria are considered linguistic variables. Decision-makers use linguistic variables to calculate the importance of the criterion and the criterion values of the alternatives according to different criteria (Chen, 2000):

Chen (2000), summarizes the TOPSIS fuzzy method algorithm as follows:

"Step 1: A committee of decision-makers is established and evaluation criteria are determined.

Step 2: The decision-makers determine the importance weights of the decision criteria and evaluate the alternatives with linguistic variables according to the determined criteria.

Step 3: The criterion weight is added to obtain the total fuzzy weight wj of the criterion Cj. Under the Cj criterion, the evaluations of the decision-makers are combined to obtain the total fuzzy criterion values ij x of the Ai alternative.

Step 4: Normalized fuzzy decision matrix and Fuzzy decision matrix are created.

Step 5 Construct the weighted normalized fuzzy decision matrix.

Step 6: Determine FPIS and FNIS

Step 7: The total distances of each alternative from FPIS and FNIS are calculated.

Step 8: Find the closeness coefficient of each alternative.

Step 9: Alternatives are ranked according to the closeness coefficient."

Application

First of all, BWM was used to obtain the data used in the study.BWM is one of the MCDM, generates weights based on the pairwise comparison of the best and worst criteria/alternatives with other alternatives/criteria (Rezaei, 2015). When it is weighted according to the importance levels with the BWM method, a guiding guide will emerge for the decision makers. Therefore, the BWM method is preferred.

Then, the process of choosing the most suitable one among the alternatives was done with the Fuzzy TOPSIS method. Expert evaluations were made by 3 academicians working in the field of tourism and 3 public officials working in the field of the sinkhole. When different studies on the subject were examined, it was seen that there was no mention of an expert limitation or a sub-number.

Within the scope of the study, it was tried to find solutions to the following questions:

1. What factors can make sinkholes a tourism destination?

2. Why might visitors choose sinkholes among many alternative tourism destinations?

3. Which of the sinkholes accepted as a geotourism destination can be the most suitable destination for visitors and investors?

The criteria for determining why tourists can choose sinkholes among many different tourism alternatives for their travels were determined by scanning the relevant literature. Statements regarding destination preference were taken from the study in which the scales of Mutinda & Mayaka (2012) were used by Davras & Uslu (2019). Table 1 was formed by shaping the statements taken by expert opinions. The determining criteria were scored using the BWM.

Table 1. Main and Sub-Criteria for Sinkholes to Be a Tourism Destination

MAIN CRITERIA		SUB-CRITERIA	
C1	Knowledge and Adventure Opportunities	C11	Visiting for the first time
		C12	The unique features of the region
		C13	New experience and different lifestyle
		C14	Increasing the level of knowledge about the region
C2	Transportation and Activity Facilities	C21	A place to go with family
		C22	Having recreational activities
		C23	Easy access
		C24	Having information about the destination
		C25	Be safe
C3	Socio-Cultural Features	C31	Open space activities
		C32	Having religious and cultural elements
		C33	Desire to meet new people
		C34	Presence of historical and archaeological sites
		C35	Far from where I live
C4	Natural Attractive Properties	C41	To meet new people
		C42	Extraordinary view
		C43	Because it is an unpolluted environment
C5	Entertainment and Recreation Facilities	C51	Being a quiet and calm place
		C52	Be a fun place
		C53	Being an interesting tourist destination

The 5 main criteria and 20 sub-criteria of these criteria stated in Table 1 above were evaluated by a total of 6 experts and calculated by formulating them in the solver add-on using the BWM Solvers Microsoft Excel add-in. Accordingly, information and adventure opportunities, transportation and activity opportunities, socio-cultural features, natural attractiveness features, entertainment and recreation opportunities were the main criteria. In the sub-criteria, there are criteria such as being visited for the first time, ease of transportation, security, distance, extraordinary view.

Table 2. Consistency Rates, Main Criteria Weights and Final Weights of Being a Tourism Destination

			MAIN CRITERIA			
DECISION MAKER	**C1**	**C2**	**C3**	**C4**	**C5**	**Ksi***
Expert 1	0,211675	0,127005	0,046016	0,524586	0,090718	0,110439
Expert 2	0,168675	0,126506	0,036145	0,415663	0,253012	0,090361
Expert 3	0,26087	0,130435	0,049689	0,385093	0,173913	0,136646
Expert 4	0,475699	0,114409	0,286022	0,042151	0,08172	0,096344
Expert 5	0,258815	0,103526	0,427607	0,172543	0,037509	0,090023
Expert 6	0,126506	0,253012	0,036145	0,415663	0,168675	0,090361
Weighted Average	**0,250373**	**0,142482**	**0,146937**	**0,32595**	**0,134258**	**0,102362**

In Table 2, the answers are given by 6 (six) different decision-makers were analyzed and the main criteria weights, consistency ratios (Ksi) and final weights were given as seen in the table above.

Since the consistency ratios (Ksi) are close to 0.1 in all, they are considered to be consistent. Considering the weighted averages, the criteria are listed as C4, C1, C3, C2, C5 from the largest to the smallest. Accordingly, natural attractiveness features had the highest average, and entertainment and recreation opportunities had the lowest weighted average.

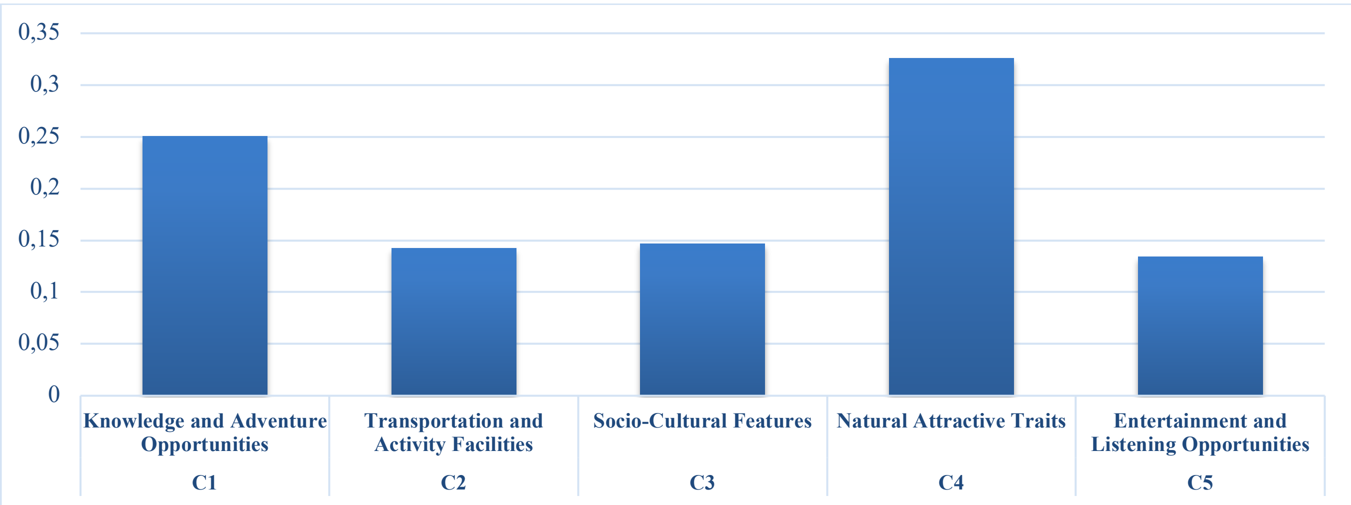

Figure 1. Weight Distributions of Main Criteria

In Figure 1, the weight distributions of the main criteria are given and the 5 main criteria are weighted. Looking at the analysis results, the main criterion, "natural attractiveness features", took the first place. This was followed by the main criteria of "knowledge and adventure opportunities" and "Socio-cultural characteristics".

Table 3. Sub Criteria Weights, Consistency Rates and Final Weights

	DECISION MAKER						
KNOWLEDGE AND ADVENTURE	**DECISION MAKER**	C11	C12	C13	C14	*Ksi**	
	Expert 1	0,053996	0,583153	0,226782	0,136069	*0,097192*	
	Expert 2	0,188341	0,484305	0,282511	0,044843	*0,080717*	
	Expert 3	0,232794	0,576923	0,050607	0,139676	*0,121457*	
	Expert 4	0,518033	0,311475	0,12459	0,045902	*0,104918*	
	Expert 5	0,226782	0,136069	0,583153	0,053996	*0,097192*	
	Expert 6	0,103916	0,600904	0,052711	0,24247	*0,126506*	
	Weighted Average	**0,220643**	**0,448805**	**0,220059**	**0,110493**	***0,104664***	
	Sub-Criteria Weights	**0,055243**	**0,112369**	**0,055097**	**0,027664**		
TRANSPORTATION AND ACTIVITY	**DECISION MAKER**	C21	C22	C23	C24	C25	*Ksi**
	Expert 1	0,124016	0,531496	0,206693	0,088583	0,049213	*0,088583*
	Expert 2	0,043478	0,5	0,152174	0,101449	0,202899	*0,108696*
	Expert 3	0,131931	0,263862	0,087954	0,470363	0,045889	*0,057361*
	Expert 4	0,442623	0,172131	0,258197	0,086066	0,040984	*0,07377*
	Expert 5	0,258815	0,172543	0,103526	0,427607	0,037509	*0,090023*
	Expert 6	0,513011	0,078067	0,208178	0,156134	0,04461	*0,111524*
	Weighted Average	**0,252312**	**0,28635**	**0,169454**	**0,2217**	**0,070184**	***0,088326***
	Sub-Criteria Weights	**0,03595**	**0,0408**	**0,024144**	**0,031588**	**0,01**	
SOCIO-CULTURAL BEING	**DECISION MAKER**	C31	C32	C33	C34	C35	*Ksi**
	Expert 1	0,154412	0,044118	0,088235	0,507353	0,205882	*0,0987*
	Expert 2	0,461538	0,288462	0,096154	0,115385	0,038462	*0,115385*
	Expert 3	0,136831	0,273663	0,078189	0,468107	0,04321	*0,079218*
	Expert 4	0,448378	0,035398	0,144543	0,289086	0,082596	*0,129794*
	Expert 5	0,428959	0,171946	0,103167	0,257919	0,038009	*0,086878*
	Expert 6	0,569145	0,044764	0,091926	0,147082	0,147082	*0,166267*
	Weighted Average	**0,366544**	**0,143058**	**0,100369**	**0,297488**	**0,09254**	***0,112704***
	Sub-Criteria Weights	**0,053859**	**0,021021**	**0,014748**	**0,043712**	**0,013598**	

Table 3. Sub Criteria Weights, Consistency Rates and Final Weights (Cont.)

	DECISION MAKER	C41	C42	C43	*Ksi**
NATURAL ATTRACTIVENESS	**Expert 1**	0,076923	0,794872	0,128205	*0,102564*
	Expert 2	0,0625	0,675	0,2625	*0,1125*
	Expert 3	0,058824	0,715686	0,22549	*0,186275*
	Expert 4	0,108333	0,083333	0,808333	*0,058333*
	Expert 5	0,058824	0,670588	0,270588	*0,141176*
	Expert 6	0,055556	0,712963	0,231481	*0,212963*
	Weighted Average	**0,07016**	**0,60874**	**0,3211**	***0,135635***
	Sub-Criteria Weights	**0,022869**	**0,198419**	**0,104662**	
	DECISION MAKER	C51	C52	C53	*Ksi**
ENTERTAINMENT AND RECREATION	**Expert 1**	0,270588	0,058824	0,670588	*0,141176*
	Expert 2	0,076923	0,128205	0,794872	*0,102564*
	Expert 3	0,066667	0,180952	0,752381	*0,152381*
	Expert 4	0,211111	0,066667	0,722222	*0,122222*
	Expert 5	0,066667	0,211111	0,722222	*0,122222*
	Expert 6	0,180952	0,066667	0,752381	*0,152381*
	Weighted Average	**0,145485**	**0,118738**	**0,735778**	***0,132158***
	Sub-Criteria Weights	**0,019532**	**0,015941**	**0,098784**	

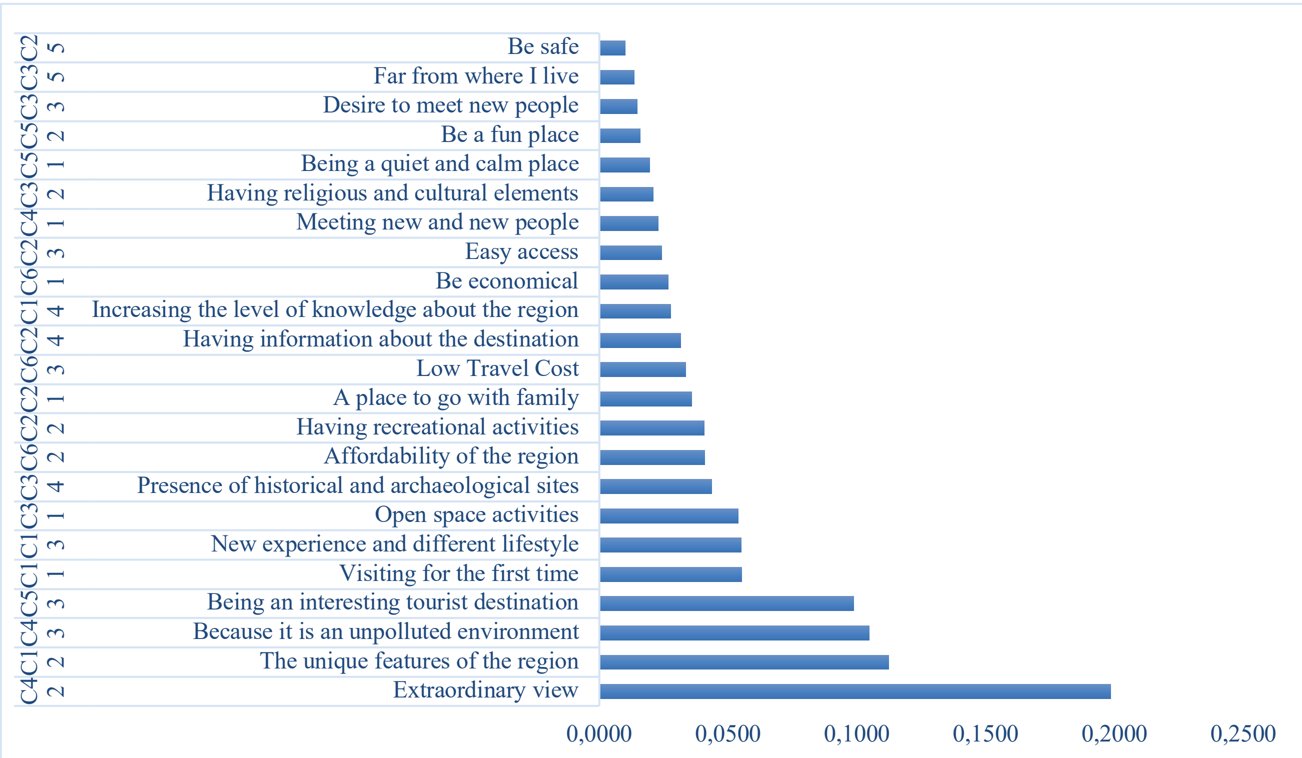

Figure 2. Weight Distributions of Sub-Criteria

The weight distributions are shown in Figure 2. As a result of the analysis, 5 main criteria and 20 sub-criteria weightings were carried out. The results are shown graphically in Figure 1, and the sub-criterion "Extraordinary landscape" has a much higher weight than the others. This criterion was followed by the items "Unique features of the region", "Uncontaminated environment" and "Being an interesting touristic place", respectively. It has been obtained from the analyzes that sinkholes have a magnificent view, which is the most important factor for a sinkhole to be a tourism destination. In the best sinkhole to be selected, sinkholes with an extraordinary view will have better multiplier weight.

The criteria that have the lowest weight and will have little impact as a tourism destination are listed from the bottom to the top as "safe", "being far from the place of residence" and the desire to meet new people, and it has been seen that it has a low weight. It has been evaluated by experts that the sinkholes will not be a safe place, and the "safety" criterion has emerged as a result of a negative effect for a sinkhole to be a tourism destination. In their study, Ekici & Özcan (2020) concluded that the participants prefer the destinations where security measures are provided for their holidays and that the participants who are married and have children give more importance to safety factors and child opportunities compared to other participants.

Table 4. Scoring of All Criteria by BWM

MAIN CRITERIA WEIGHT	MAIN CRITERIA		SUB CRITERIA WEIGHT	SUB-CRITERIA	
0,25	C1	**Knowledge and Adventure Opportunities**	0,0482	**C11**	Visiting for the first time
			0,098	**C12**	The unique features of the region
			0,048	**C13**	New experience and different lifestyle
			0,0241	**C14**	Increasing the level of knowledge about the region
0,142	C2	**Transportation and Activity Facilities**	0,0319	**C21**	A place to go with family
			0,0362	**C22**	Having recreational activities
			0,0214	**C23**	Easy access
			0,028	**C24**	Having information about the destination
			0,0089	**C25**	Be safe
0,147	C3	**Socio-Cultural Features**	0,0498	**C31**	Open space activities
			0,0194	**C32**	Having religious and cultural elements
			0,0136	**C33**	Desire to meet new people
			0,0404	**C34**	Presence of historical and archaeological sites
			0,0126	**C35**	Far from where I live
0,326	C4	**Natural Attractive Properties**	0,021	**C41**	Yeni ve To meet new people
			0,182	**C42**	Extraordinary view
			0,096	**C43**	Because it is an unpolluted environment
0,134	C5	**Entertainment and Recreation Facilities**	0,0174	**C51**	Being a quiet and calm place
			0,0142	**C52**	Be a fun place
			0,0878	**C53**	Being an interesting tourist destination

In Table 4, the main criteria and sub-criteria are combined in a single table. The best worst (BWM) analysis was carried out by 6 different experts. In the questions directed to the experts, 5 different main criteria and their sub-criteria were scored according to the best worst method among themselves.

In the second stage of the study, deciding which sinkhole will be a tourism destination is to make a group decision under multiple criteria. When making a group decision, it is appropriate to consider the possibility that the decision criteria may have different weights of importance. The fuzzy TOPSIS method, which offers suitable solutions for such situations and is one of the Fuzzy MCDM methods, forms the basis of the selected alternative being the farthest from the Fuzzy Negative Ideal Solution and the closest from the Fuzzy Positive Ideal Solution.

Precise information and data may not always be available when deciding whether a location will be a tourism destination. Sometimes it may be necessary to make a decision using incomplete information and non-numerical values. In such cases, fuzzy set theory offers suitable approaches for decision-making. In the decision-making process, when the factors that are effective in determining which sinkhole will be a tourism destination cannot be expressed with numerical values, it would be appropriate to use linguistic variables. In other words, linguistic variables can be used instead of numerical values when evaluating sinkhole alternatives. The verbal evaluations of the decision-makers are digitized by giving the membership function and calculations are made using the fuzzy TOPSIS method. Alternatives are ranked according to the obtained closeness coefficients. Thus, the difficulty of evaluating and choosing which sinkhole will be a tourism destination can be largely eliminated.

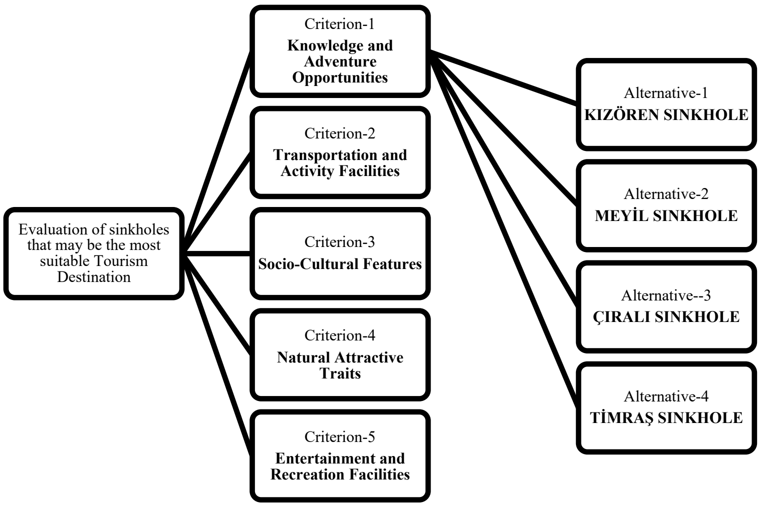

Figure 3. Sinkhole Alternatives According to the Criteria of Being a Geotourism Destination

Figure 3 shows alternative sinkholes to become a geotourism destination. These sinkholes are Kızören, Meyil, Çıralı & Timraş. Tapur & Bozyiğit (2016) gave the following information about these sinkholes (Tapur & Bozyiğit, 2016):

Kızören Sinkhole: It is located 4 km north of Kızören Town on the Konya-Aksaray road. The average height of the upper surface of the sinkhole is 1004 m, and the water surface elevation is 973 m. The long axis of the sinkhole in the east-west direction is 341 m, and the short axis in the north-south direction is 277 m. The long axis of the water surface is determined as 235 m and the short axis as 182 m. Obruk Han, which was built in the XII-XIII century, takes its name from the Kızören sinkhole near it. Obruk Han and Kızören Sinkhole are waiting to be brought into tourism. Kızören Sinkhole and the surrounding area of 127 ha were included in the contract list as Ramsar Site in 2005.

Meyil Sinkhole: It is located in Meyil Plateau, 40 km northwest of Karapınar. The ellipse-shaped sinkhole; The upper surface elevation relative to sea level is 1044 m, and the water surface elevation is 980 m. The long axis of the sinkhole in the east-west direction is 660 m, and the short axis in the north-south direction is 590 m. The water depth of the Obruk lake is 40 m and various fish live. The Slope Pitcher is also a sinkhole that can be used in a tourism destination with the infrastructure and promotion to be made in terms of its natural beauties. However, it is not known enough because it is far from the main roads, the roads reaching the lake from the main road are broken and there are no direction signs.

Çıralı Sinkhole: Obruk is located in the northwest of Karapınar. Circular-shaped sinkhole; The long axis of the upper surface is 354 m, the short axis is 303 m, the long axis of the lake surface is 135 m, and the short axis is 120 m. The upper surface elevation relative to sea level is 1070 m, the lake surface elevation is 966 m, and there is a difference of approximately 90 m between the upper surface and the lake surface. Çıralı Sinkhole has an important tourism potential with its geological formation and historical cave settlements.

Timraş Sinkhole: The Obruk is in the southeast of Çumra Gökhüyük Village. The diameter of the upper surface long axis in the north-south direction is 325 m, the short axis in the east-west direction is 245 m, the long axis of the lake surface is 242 m, and the short axis is 197 m. The upper surface elevation relative to sea level is 1035 m, the lake surface elevation is 1005 m, and there is a difference of approximately 25 m between the upper surface and the lake surface. The water depth of the sinkhole is 40 m. There are carp-type fishes because of the freshwater of the Obruk lake. The caves and cavities on the slopes of the sinkhole, which has a large number of visitors due to its proximity to the road, are the living spaces of pigeons.

As seen in Figure 3 above, within the scope of the study, the 5 main criteria weighted with BWM are the academicians working in the field of tourism and the public personnel working on the sinkholes, by 7 different experts (4 academics in the field of tourism, 1 travel guide and 2 people, public personnel with knowledge of the sinkholes in the region). According to the fuzzy TOPSIS method, the lowest 1 point and the highest 7 points were scored. The analysis results are given below step by step:

The Steps of the Fuzzy TOPSIS Method:

Step 1: First, create the decision matrix.

Within the scope of the study, 5 criteria were listed for 4 alternatives according to the FUZZY TOPSIS method. Table 5 below shows the weight and type of criteria assigned for each criterion.

Table 5. Characteristics of Criteria

	Name	**type**	**Weight**
1	Knowledge and Adventure Opportunities	+	(0.250,0.250,0.250)
2	Transportation and Activity Facilities	+	(0.142,0.142,0.142)
3	Socio-Cultural Features	+	(0.147,0.147,0.147)
4	Natural Attractive Properties	+	(0.326,0.326,0.326)
5	Entertainment and Recreation Facilities	+	(0.134,0.134,0.134)

Table 6 contains the analysis results showing the fuzzy scale used in the model.

Table 6. Fuzzy Scale

Code	**Linguistic terms**	**L**	**M**	**U**
1	Very low	0	0	1
2	Low	0	1	3
3	Moderately low	1	3	5
4	Moderate	3	5	7
5	Moderately high	5	7	9
6	High	7	9	10
7	Very high	9	10	10

Figure 4. General View of the Kızören Sinkhole (www.aa.com.tr)

Figure 5. General View of the Meyil Sinkhole (Waltham 2015)

Figure 6. General View of Çıralı Sinkhole (Waltham 2015)

Figure 7. General View of Tımraş Sinkhole (Günay et al. 2015)

The results of the decision matrix are shown in Table 7, by evaluating the alternatives through various criteria. In the evaluation the matrix represents the arithmetic mean of all experts.

Table 7. Decision Matrix

	Knowledge and Adventure Opportunities	**Transportation and Activity Facilities**	**Socio-Cultural Features**	**Natural Attractive Properties**	**Entertainment and Recreation Facilities**
KIZÖREN SINKHOLE	(6.429,8.143,9.143)	(4.714,6.571,8.000)	(7.571,9.000,9.571)	(7.571,9.143,9.857)	(3.143,5.000,6.714)
MEYİL SINKHOLE	(3.286,4.857,6.571)	(2.000,3.857,5.857)	(3.429,5.286,7.143)	(3.571,5.571,7.571)	(0.429,1.714,3.571)
ÇIRALI SINKHOLE	(4.714,6.571,8.143)	(2.714,4.714,6.714)	(4.143,6.143,7.857)	(5.857,7.714,9.143)	(1.143,2.714,4.714)
TİMRAŞ SINKHOLE	(4.000,5.857,7.714)	(3.286,5.143,6.857)	(3.571,5.571,7.286)	(5.286,7.143,8.857)	(2.286,3.571,5.143)

Step 2: It is necessary to create the normalized decision matrix

Based on positive and negative ideal solutions, a normalized decision matrix can be calculated using the following formulas:

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right) \quad ; \quad c_j^* = max_i\, c_{ij} \text{ ; } \textit{Positive ideal solution}$$

$$\tilde{r}_{ij} = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right) \quad ; \quad a_j^- = min_i\, a_{ij} \text{ ; } \textit{Negative ideal solution}$$

The normalized decision matrix is shown in the table below.

Table 8. A normalized decision matrix

	Knowledge and Adventure Opportunities	Transportation and Activity Facilities	Socio-Cultural Features	Natural Attractive Properties	Entertainment and Recreation Facilities
KIZÖREN SINKHOLE	(0.703,0.891,1.000)	(0.589,0.821,1.000)	(0.791,0.940,1.000)	(0.768,0.928,1.000)	(0.468,0.745,1.000)
MEYİL SINKHOLE	(0.359,0.531,0.719)	(0.250,0.482,0.732)	(0.358,0.552,0.746)	(0.362,0.565,0.768)	(0.064,0.255,0.532)
ÇIRALI SINKHOLE	(0.516,0.719,0.891)	(0.339,0.589,0.839)	(0.433,0.642,0.821)	(0.594,0.783,0.928)	(0.170,0.404,0.702)
TİMRAŞ SINKHOLE	(0.437,0.641,0.844)	(0.411,0.643,0.857)	(0.373,0.582,0.761)	(0.536,0.725,0.899)	(0.340,0.532,0.766)

Step 3: Create the weighted normalized decision matrix

Considering the different weights of each criterion, the weighted normalized decision matrix can be calculated by multiplying the weight of each criterion in the normalized fuzzy decision matrix, according to the following formula.

$\tilde{v}_{ij} = \tilde{r}_{ij}.\tilde{w}_{ij}$

Where $\tilde{w}_{ij}$ represents the weight of criterion c_j

The following table shows the weighted normalized decision matrix

Table 9. The weighted normalized decision matrix

	Knowledge and Adventure Opportunities	Transportation and Activity Facilities	Socio-Cultural Features	Natural Attractive Properties	Entertainment and Recreation Facilities
KIZÖREN SINKHOLE	(0.176,0.223,0.250)	(0.084,0.117,0.142)	(0.116,0.138,0.147)	(0.250,0.302,0.326)	(0.063,0.100,0.134)
MEYİL SINKHOLE	(0.090,0.133,0.180)	(0.036,0.069,0.104)	(0.053,0.081,0.110)	(0.118,0.184,0.250)	(0.009,0.034,0.071)
ÇIRALI SINKHOLE	(0.129,0.180,0.223)	(0.048,0.084,0.120)	(0.064,0.094,0.121)	(0.194,0.255,0.302)	(0.023,0.054,0.094)
TİMRAŞ SINKHOLE	(0.110,0.160,0.211)	(0.059,0.092,0.122)	(0.055,0.086,0.112)	(0.175,0.236,0.293)	(0.046,0.071,0.103)

Step 4: It is necessary to determine the fuzzy positive ideal solution (FPIS, A*) and the fuzzy negative ideal solution ($FNIS, A^{-}$).

The FPIS and FNIS of the alternatives can be defined as follows:

$$A^{*} = \{\tilde{v}_1^{*}, \tilde{v}_2^{*}, \dots, \tilde{v}_n^{*}\} = \left\{\left(\max_j v_{ij} \mid i \in B\right), \left(\min_j v_{ij} \mid i \in C\right)\right\}$$

$$A^{-} = \{\tilde{v}_1^{-}, \tilde{v}_2^{-}, \dots, \tilde{v}_n^{-}\} = \left\{\left(\min_j v_{ij} \mid i \in B\right), \left(\max_j v_{ij} \mid i \in C\right)\right\}$$

Where $\tilde{v}_i^{*}$ is the max value of all the alternatives and $\tilde{v}_1^{-}$ is the min value of i for all the alternatives. *B* and *C* represent the positive and negative ideal solutions, respectively.

The positive and negative ideal solutions are shown in the table below.

Table 10. The positive and negative ideal solutions

	Positive ideal	Negative ideal
Knowledge and Adventure Opportunities	(0.176,0.223,0.250)	(0.090,0.133,0.180)
Transportation and Activity Facilities	(0.084,0.117,0.142)	(0.036,0.069,0.104)
Socio-Cultural Features	(0.116,0.138,0.147)	(0.053,0.081,0.110)
Natural Attractive Properties	(0.250,0.302,0.326)	(0.118,0.184,0.250)
Entertainment and Recreation Facilities	(0.063,0.100,0.134)	(0.009,0.034,0.071)

Step 5: Calculate the distance between each alternative and the fuzzy positive ideal solution A^{*} and the distance between each alternative and the fuzzy negative ideal solution A^{-}

The distance between each alternative and FPIS and the distance between each alternative and FNIS are respectively calculated as follows:

$S_i^* = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^*) \quad i=1,2,\dots,m$

$S_i^- = \sum_{j=1}^{n} d(\tilde{v}_{ij}, \tilde{v}_j^-) \quad i=1,2,\dots,m$

d is the distance between two fuzzy numbers, when given two triangular fuzzy numbers (a_1, b_1, c_1) and (a_2, b_2, c_2), e distance between the two can be calculated as follows:

$$d_v(\tilde{M}_1, \tilde{M}_2) = \sqrt{\frac{1}{3}[(a_1 - a_2)^2 + (b_1 - b_2)^2 + (c_1 - c_2)^2]}$$

Note that $d(\tilde{v}_{ij}, \tilde{v}_j^*)$ and $d(\tilde{v}_{ij}, \tilde{v}_j^-)$ are crisp numbers.

The table below shows the distance from positive and negative ideal solutions

Table 11. Distance from positive and negative ideal solutions

	Distance from the positive ideal	Distance from the negative ideal
KIZÖREN SINKHOLE	0	0.354
MEYİL SINKHOLE	0.354	0
ÇIRALI SINKHOLE	0.2	0.156
TİMRAŞ SINKHOLE	0.22	0.137

Step 6: Calculate the closeness coefficient and rank the alternatives

The closeness coefficient of each alternative can be calculated as follows:

$$CC_i = \frac{S_i^-}{S_i^+ + S_i^-}$$

The best alternative is closest to the FPIS and farthest to the FNIS. The closeness coefficient of each alternative and the ranking order of it are shown in the table below.

Table 12. Closeness coefficient

	Ci	rank
KIZÖREN SINKHOLE	1	1
MEYİL SINKHOLE	0	4
ÇIRALI SINKHOLE	0.437	2
TİMRAŞ SINKHOLE	0.384	3

The following graph shows the closeness coefficient of each alternative.

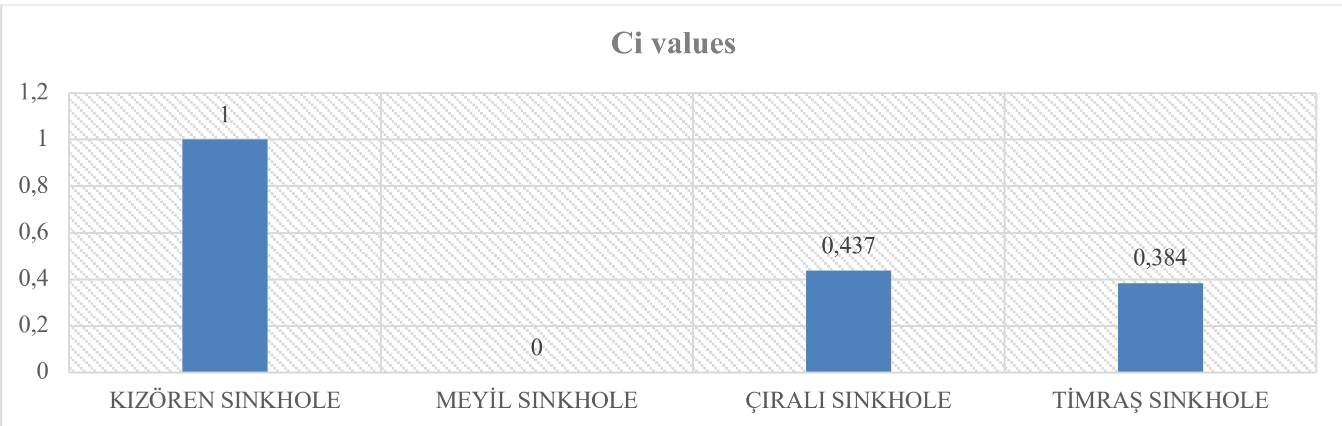

Figure 8. Closeness coefficient graph

As a result of the analyzes obtained from the fuzzy TOPSIS method, it can be said that "Kızören Sinkhole" meets the criteria of being a tourism destination more than the other three sinkholes.

This situation has been at the forefront due to the extraordinary view of the Kızören sinkhole, the unique characteristics of its environment, and the fact that it is an unpolluted environment, that is, the natural attractiveness features predominate. The Kızören sinkhole was followed by the Çıralı and Timraş sinkholes, respectively. On the other hand, it has been observed that the Meyil Sinkhole does not meet many of the criteria for being a tourism destination.

Results and Discussion

In this researches, which aims to contribute to the investments to be made in tourism destinations in the most appropriate place, the sinkholes that arouse excitement and fear in people and that they may want to see with curiosity were examined. Within the scope of the study, answers were sought to three questions:

Which factors can make sinkholes a tourism destination?

Why might visitors choose sinkholes among many alternative tourism destinations?

Which of the sinkholes, which are accepted as geotourism destinations, can be the most suitable destination for visitors and investors?

In this direction, the main criteria and sub-criteria that a place must meet to be a tourism destination have been scored by various experts according to BWM.

As a result of the scoring, the main criteria of "Natural Attractive Properties", "Knowledge and Adventure Opportunities" and "Socio-cultural characteristics" were the main criteria with the highest weight, respectively. “Extraordinary view, “The unique features of the region”, “Uncontaminated environment” and “Being an interesting tourist destination” items were the sub-criteria with the highest weight. Then, Kızören, Çıralı, Meyil and Timraş sinkholes, which are thought to have the most tourist attraction potential, were analyzed with the fuzzy TOPSIS method. As a result of the analysis, it was concluded that the Kızören sinkhole has the potential to be a tourism destination at a greater rate than other sinkoles.

It is thought that bringing the Kızören Sinkhole into tourism, it can contribute to the socio-economic and cultural structure of the local people as well as local and foreign tourists. It is thought that the number of tourism resource (where tourists can go) be increased by including the sinkholes in the planning of the Destination Management Organizations. In 2009, Cay et al. carried out tourism information system inventory studies on another Obruk Lake, Gökhöyük, and searched for tourism zoning plan, water analysis, three-dimensional photogrammetric design and geological examination, etc. for the Tourism Plan Information System. They said that such activities can be projected. They also determined that the Obruk Lake was visited by tourists, but there were inadequacies in the facility. They argued that by attracting attention to investments in the region, which has a high touristic attraction, thanks to their studies, economic and cultural contributions can be made to the region (Cay et al, 2009). A similar structure can be created for the Kızören Sinkhole. However, although a protection measure was taken with barbed wire around some of the sinkholes, these barbed wire poles were destroyed in many places and lost their importance. For this reason, protection curtains and warning signs should be placed on the edge of the sinkholes that pose danger in a short time. While these are being done, a door mechanism should be built in the section with solid ground, considering the visitors who will come to the sinkhole (Tapur & Bozyiğit, 2015). By turning the sinkhole areas into a geopark, various nature sports such as hiking and climbing can be done in the region. However, for this, security must be ensured first.

Because the formation of some sinkholes has not been completed, collapses can still occur. This poses a great danger to visitors and even local people.

This study was carried out on four different sinkholes. Future studies can make a comparison over similar sinkholes in the world. It will be possible to make different decisions by determining new alternative criteria.

Conclusion

This article is important in that it presents a fuzzy multi-criteria decision-making model for the first time to analyze the potential of Konya province sinkholes to be a tourism destination.

The sinkholes are very interesting structures, both geologically and touristically, in terms of their formation, structures and insatiable viewing beauties. The sinkholes, which are feared structures that threaten agricultural lands by the people living in the region, are actually natural wonders. Therefore, instead of being afraid of sinkholes, it should be opened to tourism, turned into a geopark, offered to the service of all humanity and left as a geological heritage to future generations. Accepting the region as a natural protected area, therefore paying attention to the ecological structure is very important in terms of supporting sustainable tourism. The supply of materials from these areas should be prohibited. Roads should be improved, promotional signs should be placed and environmental protection reminders should be made. Events such as press, internet, festivals, festivals, fairs, exhibitions, symposiums and congresses should be organized and the richness of the region should be promoted. A list of morphological natural values should be drawn up, their coordination with other riches should be ensured, and long-term development planning should be made. Safari and trekking, amateur and scientific nature observations and studies should be provided. A promotion center should be established by the relevant tourism units, and experts who know foreign languages and geomorphology should be present in the center. Educational and recreational facilities should be available to visitors. While planning the tourism investments to be realized, care should be taken not to destroy the natural environment. It is necessary to ensure that Konya has great potential in the field of faith tourism and that domestic and foreign tourists coming to the city do not leave without seeing natural wonders such as sinkholes. Many sinkholes in Konya can be brought into geotourism with appropriate and correct investments. The opening of every interesting geological formation to tourism may not be positive. The protection of these areas is also of great importance. It should not be forgotten that opening such areas to touristic activities will accelerate the deterioration of the natural environment. In other words, opening every interesting formation to tourism may not be positive.

Decleration

This study was ethically approved by the Scientific Ethics and Evaluation Committee of Selçuk University, Faculty of Tourism, with the decision dated 25.11.2021 and numbered 36.

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SELÇUK ÜNİVERSİTESİ
TURİZM FAKÜLTESİ
BİLİMSEL ETİK VE DEĞERLENDİRME KURULU

TOPLANTI TARİHİ: 25/11/2021

TOPLANTI GÜNDEMİ: Öğr. Gör. Dr. Münevver ÇİÇEKDAĞI Etik Kurul Başvuru Değerlendirmesi

KARAR 36: Turizm Fakültesi Öğretim Elemanı Öğr. Gör. Dr. Münevver ÇİÇEKDAĞI'nın "Sinkholes (Obruk) as a Geotourism Destination: An Application with Integrated Fuzzy TOPSIS and Best Worst Method" başlıklı çalışması için araştırmada kullanmak üzere uygulayacağı ölçek/anket, içerik vb. Selçuk Üniversitesi, Turizm Fakültesi, Bilimsel Etik ve Değerlendirme Kurulu tarafından **UYGUN GÖRÜLMÜŞTÜR.**

Bu karar, toplantıya katılanların ~~oy çokluğu~~ / oy birliği ile kabul edilmiştir.

Prof. Dr. Şafak ÜNÜVAR
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25. 11. 2021