Research Article
Journal of Marine and Engineering Technology (JOINMET) 1(1), 34-41, 2021
Recieved: 12-Jun-2021 Accepted: 20-Jun-2021

SAKARYA UNIVERSITY OF APPLIED SCIENCES

AHP and Grey Relations Analysis Based Sightseeing Boat Selection for Summer Tourism Activities

Muhammet Enes AKPINAR[1*], Mustafa GERŞİL[2]

[1] Manisa Celal Bayar University, Department of Industrial Engineering, enes.akpinar@cbu.edu.tr
[2] Manisa Celal Bayar University, Department of Business Administration, mustafa.gersil@cbu.edu.tr

ABSTRACT

Decision problems are different problems that we face at every stage of our lives. These problems sometimes arise at the time of a purchase, and sometimes when an important decision has to be made. Due to the nature of this problem, decision makers want to make the most appropriate decision for themselves. The difficulty in deciding the best among many alternatives for this decision complicates the problem. This problem is known as a multi-criteria decision-making problem in the literature. The problem of obtaining a sightseeing boat for a tourism business's summer activities is examined in this paper. The analytical hierarchy process method was used to determine the criterion weights for the problem solution. Afterwards, alternative sightseeing boats were evaluated with gray relations analysis. According to the results of the calculations, the most suitable sightseeing boat was decided and the results were interpreted.

Keywords: Sightseeing boat selection, multi-criteria decision making, analytical hierarchy process, grey relations analysis.

AHP ve Gri İlişkiler Analizi Temelli Yaz Turizm Aktiviteleri için Gezi Teknesi Seçimi

ÖZ

Karar problemleri hayatımızın her aşamasında karşılaştığımız farklı problemlerdir. Bu problemler kimi zaman bir satın alma anında kimi zaman ise önemli bir kararın verilmesi gerektiğinde karşımıza çıkmaktadır. Bu problemin doğası gereği karar vericiler kendileri için en uygun kararı vermek isterler. Bu karar için birçok alternatif arasından en iyi olanına karar vermedeki zorluk problemi zorlaştırmaktadır. Literatürde bu problem çok kriterli karar verme problemi olarak geçmektedir. Bu çalışmada bir turizm işletmesinin yaz aktiviteleri için gezi teknesi satın alım problem ele alınmıştır. Ele alınan problemin çözümü analitik hiyerarşi süreci yöntemi ile kriter ağırlıkları belirlenmiştir. Sonrasında gri ilişkiler analizi ile alternatif gezi tekneleri değerlendirilmiştir. Yapılan hesaplamalar sonucuna göre en uygun yolcu teknesine karar verilmiş ve sonuçlar yorumlanmıştır.

Anahtar Kelimeler: Gezi teknesi seçimi, çok kriterli karar verme, analitik hiyerarşi süreci, gri ilişkiler analizi.

* Corresponding author's email: enes.akpinar@cbu.edu.tr

1 Introduction

Sea tourism is a type of tourism preferred by many domestic and foreign tourists, especially in the summer months. Although there are different activities in this type of tourism, traveling by boat is an indispensable part of this tourism. Thanks to this activity, tourists can reach places they cannot go with their cars and have the opportunity to see natural beauties. However, the fact that this activity can be done either alone or with a large group is another reason for preference.

In the decision-making phases we meet in our daily lives, Multi-Criteria Decision Making (MCDM) difficulties provide great convenience to the decision-maker. While this convenience is provided, the fact that there are many methods and each method gives different results to the decision-maker makes things easier. In a decision process, there may be many products that are desired to be purchased. When deciding on the most suitable of these products, you need to consider many criteria. For this reason, it is a difficult problem to determine the most suitable alternative for these criteria. For its solution, MCDM methods are the most appropriate methods.

Analytical Hierarchy Process (AHP) and Gray Relationship Analysis (GRA) methods were used in the literature in different types of problems. AHP methodology has been used in the literature in computer selection [1], risk analysis [2], evaluation of energy production technologies [3], Industry 4.0 applications [4], evaluation of entrepreneurship projects [5], evaluation of airlines [6], evaluation of the priorities of sustainable consumption and production in the supply chain [7], and the projects evaluation [8]. For further studies on AHP, the study of Khari and Dwivedi [9] is proposed in the literature.

In the literature, the GRA method is used in carbon emission estimation [10], supplier selection [11], machine selection [12], economic evaluation in European Union countries [13], It has been used in vendor selection [14], wastewater treatment process selection [15], sustainable energy production [16] and reducing the risks in traffic accidents [17]. For more studies on GRA see Kuo [18].

As it is seen in the literature studies, no study has been found related to the use of GRA in sightseeing boat selection processes before. In this study, the process of buying a new sightseeing boat of a tourism business is discussed. The company manager in the problem addressed is the decision-maker. First of all, criterion weights were determined by the decision-maker with AHP. Afterwards, the most suitable sightseeing boat was selected among the alternative ships with the GRA method.

The remainder of the paper is structured as follows. The AHP approach which was utilized in the study and provides convenience in the stage of calculating weight is explained in the second section. The steps of the GRA technique are described in the third section. The problem's structure is discussed in the fourth chapter. The results are analyzed and future research directions are mentioned in the final section.

2 Analytical Hierarchy Process

AHP, which is one of the most used methods in solving decision making problems today, was developed by Saaty in 1980. AHP, one of the MCDM techniques, enables quantitative and qualitative variables to be evaluated together, taking into account the priorities of decision makers. There are 5 basic steps in the AHP method. These steps are to form the structure of the problem, to create pairwise comparison matrices, to find priority vectors, to check the consistency of judgments in comparison matrices and to calculate the order of alternatives. These basic steps are briefly summarized below [19].

Step 1: Determine the criteria to be examined within the scope of the problem to be solved and the sub-criteria belonging to these criteria.

Step 2: After the decision hierarchy is established, binary comparison matrices are created to calculate the importance of the criteria relative to each other. Binary comparisons are made by decision-makers according to the nine-point evaluation scale developed by Saaty. Table 1 includes this scale and its verbal equivalents.

Step 3: After the binary comparison matrices are filled by the decision makers, the eigen vectors are created.

Step 4: After calculating the priority vector, the consistency of each comparison matrix filled is examined. In order to measure whether the decision makers behave consistently while filling the comparison matrices, Consistency Ratio - CR should be calculated in all comparison matrices. The following equation is used for the CR calculation:

$$CI = \frac{\lambda_{\max} - n}{(n-1) \times RI} \tag{1}$$

Step 5: The importance weights of the criteria according to each other and the alternatives according to each criterion are found in the first 3 steps, and after the consistency ratio is less than 0.1, the matrix is created in which the importance weights of the alternatives are shown according to each criterion. The ranking of the alternatives is obtained by multiplying this matrix with the matrix containing the importance weights of the criteria.

Table 1: *Analytical hierarch process scale*

Importance Level	Definition	Explanation
1	Equally	The items contribute equally important to the purpose.
3	Moderate important	As a result of experience and evaluations, one criterion is more preferred than the other.
5	Strong important	As a result of experience and evaluations, one criterion is much more preferred than the other.
7	Very Strong	One criterion is strongly preferred over another.
9	Highly important	One criterion is preferred to the highest possible degree over another.
2-4-6-8	Interval values	If the words are insufficient to make the evaluation, the value in the middle of the numerical values is given.

3 Grey Relations Analysis

The gray system theory was first introduced in 1982 by Professor Julong Deng, a faculty member at Hua Chung University of Science and Technology in Thailand. The term gray refers to weak, incomplete and uncertain, and the expression gray is often used in relation to the concept of knowledge. In system control theory; The system in which the relevant information is known is called the white system, the system in which the relevant information is not completely known is called the black system while any system between these boundaries is referred to as the gray system [20].

GRA is one of the sub-titles of gray modeling and is a method for determining the degree of relationship between each factor and the compared factor series in a gray system. Each factor is defined as an array. The degree of influence between factors is called the gray relational degree. GRA solves MCDM problems by combining the entire order of performance criterion values considered for each alternative in a single value. It transforms the original problem into a single criterion decision problem. Thus, multi-criteria alternatives can be easily compared after the GRA process [21].

GRA has been successfully applied in solving different types of MCDM problems, such as planning the retrofit of power distribution systems, controlling the integrated circuit marking process, modeling the quality propagation function. The GRA steps are as follows [22]:

Step 1: At this stage, mxn decision matrix is created by determining m alternatives (i=1.2,…,m) and n criteria (j= 1,2,…n).

Step 2: It is the stage of creating the series that will be used to provide comparison by finding the minimum or maximum values of the series. Sometimes, decision-makers may determine reference values themselves rather than taking the highest or lowest value, but this method is not preferred much [21].

Step 3: This phase is also called the standardization phase. Here, three different equations can be used depending on whether the large value is better (2), the small value is better (3) and the optimal value is better (4).

$$x_i^* = \frac{x_{ij} - \min_j x_{ij}}{\max_j x_{ij} - \min_j x_{ij}} \tag{2}$$

$$x_i^* = \frac{\max_j x_{ij} - x_{ij}}{\max_j x_{ij} - \min_j x_{ij}} \tag{3}$$

$$x_i^* = \frac{x_{ij} - x_{0j}}{\min_j x_{ij} - x_{0j}} \tag{4}$$

Step 4: The absolute value matrix is created. While creating this matrix, the values in the normalization matrix are subtracted from the reference series.

Step 5: Gray relational coefficient matrix is created with the help of Equation 5.

$$\gamma_{ij} = \frac{\Delta_{\min} + \zeta\Delta_{\max}}{\Delta_{ij} + \zeta\Delta_{\max}} \tag{5}$$

Here, Δ_{min} and Δ_{max} are the smallest and largest values in the absolute difference matrix created in the previous step. ζ is used as the discriminating coefficient. This coefficient takes values between 0 and 1. If it is selected close to 1, the discrimination will approach the upper level. When close to 0 is selected, the discrimination approaches the lower level. In the literature, this coefficient is generally accepted as 0.5 [23].

Step 6: Gray relational degrees are calculated. When making this calculation, the gray relational coefficients are multiplied by the criterion weights. There are two situations here. If the criteria weights are equal, equation (6) is used, if there are different criteria weights (w_i) determined by the decision maker, equation (7) is used.

$$\Gamma_i = \frac{1}{n}\sum_{j=1}^{n} \gamma_{ij} \tag{6}$$

$$\Gamma_i = \frac{1}{n}\sum_{j=1}^{n} w_i\gamma_{ij} \tag{7}$$

4 Sightseeing Boat Selection using AHP and GRA

In this part of the study, the definition of the problem and the solution stages are mentioned. The sightseeing boat selection problem for a tourism agency operating in the Urla district of Izmir is discussed in this study. This agency gives tourists a tour of the bays of Urla district during the summer months. In this context, it is planned to purchase a boat in addition to the existing sightseeing boats. For this, the owner of the company has researched the boots on the market according to the criteria he has determined. According to the results of this research, five different bots were determined according to their criteria. In order to decide on the most suitable one of these boots, first of all, the criteria weights were determined and then the final selection was made with the GRA method. The criteria determined by the decision maker are given in Table 2.

In line with the determined criteria, first of all, criteria weights were determined by the AHP method. The initial matrix for the criterion weights is given in Table 3. The final criterion weight values are given in Figure 1.

Table 2: *Boat selection criteria*

Criteria	**Definition**
Criteria 1 (B_1)	Sitting capacity for passenger
Criteria 2 (B_2)	Number of bed capacity for sunbathing
Criteria 3 (B_3)	Number of dressing cabins
Criteria 4 (B_4)	Number of toilets and showers
Criteria 5 (B_5)	Price

Table 3: *Initial matrix of AHP*

Criteria	(B_1)	(B_2)	(B_3)	(B_4)	(B_5)
(B_1)	-	4	2	2	2
(B_2)	1/4	-	2	2	1
(B_3)	1/2	1/2	-	3	1
(B_4)	1/2	1/2	1/3	-	1
(B_5)	1/2	1	1	1	-

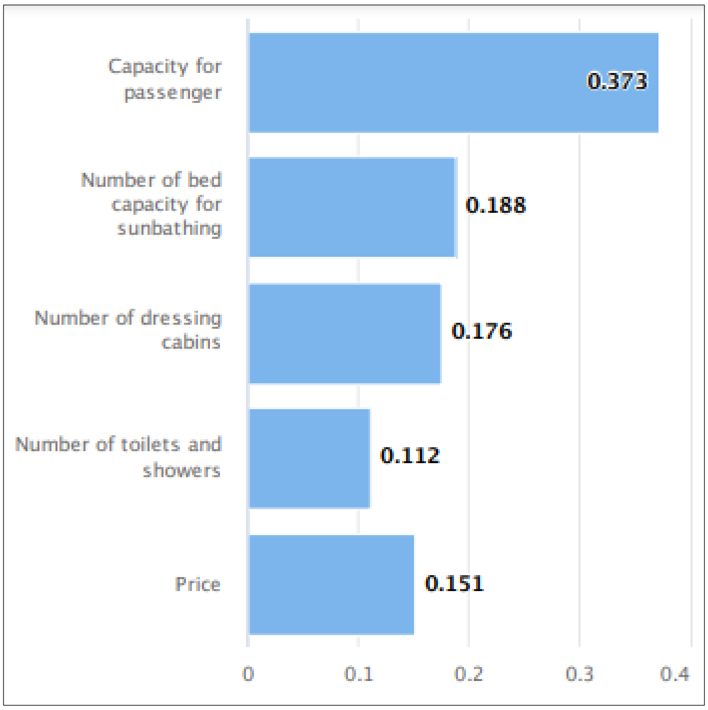

Figure 1. Final weights of the criteria

When the criteria weights are examined, it is seen that the criterion with the highest weight value is the capacity for the passengers. Then there was the bed capacity and dressing cabin. Fourth, the price criterion has come to the fore. Finally, the number of toilets and showers was an important criterion. Considering the criterion weights, the most suitable one among the alternative boats was decided with the GRA method. For this, first of all, each alternative was evaluated by the decision maker with the help of Table 4 and the results are given in Table 5.

Table 4: *Linguistic evaluation values* [24]

Linguistic values	Short form
Too weak	TW
Weak	W
Moderate weak	MW
Moderate	M
Moderate good	MG
Good	G
Very good	VG

Table 5: *Decision matrix of the criteria and alternatives*

Criteria	Boat-1	Boat-2	Boat-3	Boat-4	Boat-5
(B_1)	VG	G	M	MG	G
(B_2)	M	VG	M	MG	VG
(B_3)	MW	G	TW	M	VG
(B_4)	W	VG	TW	G	M
(B_5)	M	VG	MW	G	G

Equal weighted mean defuzzification was used to defuzzify gray numbers. A reference series was created to be used in the normalization of the decision matrix. The reference series was found by taking the maximum value of each criterion. After the decision matrix and reference series were obtained, the normalization process was performed. In the calculation of gray relational degrees, the gray relational coefficient matrix values should be multiplied by the criterion weights. After the criteria are multiplied by the weights for each alternative, gray associative grades are obtained. The gray relational degrees and rankings obtained according to the GRA method are given in Table 6. As can be seen in Table 6, the best alternative was seen as the second boat. After the 2nd bot, the 5th, 4th, 1st and 3rd bots, respectively, are the other best alternatives. The decision maker can buy the 2nd Boat for summer tourism activities.

Table 6: *Final ranking of the boats using GRA*

Alternatives	Grey relational degree	Ranking
Boat-1	0,583	4
Boat-2	0,628	1
Boat-3	0,571	5
Boat-4	0,598	3
Boat-5	0,611	2

5 Conclusions

Although tourism activities vary, sea tourism has an important share in Turkey. This type of tourism consists of many activities. Especially traveling by sightseeing boat is one of the indispensable activities in this tourism. There are not many studies on boat selection in the literature. Therefore, the motivation for this study is that there is no study in this field. However, in this study, AHP and GRA methods were used as hybrids. In the study, a sightseeing boat selection problem in İzmir province is discussed. In the problem addressed, first of all the criteria were determined by the decision maker. AHP method was used for the weight values of the determined criteria. Afterwards, the most appropriate one was decided by considering the alternatives determined by the decision maker with the GRA method. It was seen that the most suitable one among the five different alternatives was the second alternative. The limited number of criteria and alternatives in the study are the limitations of the study. Solving the study with a mathematical model or different MCDM methods can be considered for further research.

References

[1] S. Abadi *et al.*, “Implementation of fuzzy analytical hierarchy process on notebook selection,” *Int. J. Eng. Technol.*, 2018, doi: 10.14419/ijet.v7i2.27.12047.

[2] G. K. Koulinas, P. K. Marhavilas, O. E. Demesouka, A. P. Vavatsikos, and D. E. Koulouriotis, “Risk analysis and assessment in the worksites using the fuzzy-analytical hierarchy process and a quantitative technique – A case study for the Greek construction sector,” *Saf. Sci.*, 2019, doi: 10.1016/j.ssci.2018.10.017.

[3] S. Kheybari, F. M. Rezaie, S. A. Naji, and F. Najafi, “Evaluation of energy production technologies from biomass using analytical hierarchy process: The case of Iran,” *J. Clean. Prod.*, 2019, doi: 10.1016/j.jclepro.2019.05.357.

[4] A. Sevinç, Ş. Gür, and T. Eren, “Analysis of the difficulties of SMEs in industry 4.0 applications by analytical hierarchy process and analytical network process,” *Processes*, 2018, doi: 10.3390/pr6120264.

[5] Z. D. Unutmaz Durmuşoğlu, “Assessment of techno-entrepreneurship projects by using Analytical Hierarchy Process (AHP),” *Technol. Soc.*, 2018, doi: 10.1016/j.techsoc.2018.02.001.

[6] I. Badi and A. Abdulshahed, “Ranking the libyan airlines by using full consistency method (fucom) and analytical hierarchy process (ahp),” *Oper. Res. Eng. Sci. Theory Appl.*, 2019, doi: 10.31181/oresta1901001b.

[7] S. K. Mangla, K. Govindan, and S. Luthra, “Prioritizing the barriers to achieve sustainable consumption and production trends in supply chains using fuzzy Analytical Hierarchy Process,” *J. Clean. Prod.*, 2017, doi: 10.1016/j.jclepro.2017.02.099.

[8] M. Rashidi, M. Ghodrat, B. Samali, B. Kendall, and C. Zhang, “Remedial modelling of steel bridges through application of analytical hierarchy process (AHP),” *Appl. Sci.*, 2017, doi: 10.3390/app7020168.

[9] A. Khaira and R. K. Dwivedi, “A State of the Art Review of Analytical Hierarchy Process,” 2018, doi: 10.1016/j.matpr.2017.11.663.

[10] Y. Huang, L. Shen, and H. Liu, “Grey relational analysis, principal component analysis and forecasting of carbon emissions based on long short-term memory in China,” *J. Clean. Prod.*, 2019, doi: 10.1016/j.jclepro.2018.10.128.

[11] T. K. Wang, Q. Zhang, H. Y. Chong, and X. Wang, “Integrated supplier selection framework in a resilient construction supply chain: An approach via analytic hierarchy process (AHP) and grey relational analysis (GRA),” *Sustain.*, 2017, doi: 10.3390/su9020289.

[12] “A hybrid approach based on ANP and grey relational analysis for machine selection,” *Teh. Vjesn. - Tech. Gaz.*, 2017, doi: 10.17559/tv-20141123105333.

[13] Z. X. Wang and P. Y. Yao, “Grey relational analysis of economic policy uncertainty in selected European Union countries,” *Econ. Comput. Econ. Cybern. Stud. Res.*, 2018, doi: 10.24818/18423264/52.2.18.15.

[14] S. S. Weng, K. Y. Chen, and C. Y. Li, “Application of the analytic hierarchy Process and grey relational analysis for vendor selection of spare parts planning software,” *Symmetry (Basel).*, 2019, doi: 10.3390/sym11091182.

[15] A. Karimi, B. Ahmadpour, and M. R. Marjani, “Using the Fuzzy Grey Relational Analysis

Method in Wastewater Treatment Process Selection," *Iran. J. Heal. Saf. Environ.*, 2018.

[16] H. Malekpoor, K. Chalvatzis, N. Mishra, M. K. Mehlawat, D. Zafirakis, and M. Song, "Integrated grey relational analysis and multi objective grey linear programming for sustainable electricity generation planning," *Ann. Oper. Res.*, 2018, doi: 10.1007/s10479-017-2566-4.

[17] Y. Liu, X. Huang, J. Duan, and H. Zhang, "The assessment of traffic accident risk based on grey relational analysis and fuzzy comprehensive evaluation method," *Nat. Hazards*, 2017, doi: 10.1007/s11069-017-2923-2.

[18] T. Kuo, "A review of some modified grey relational analysis models," *Journal of Grey System*. 2017.

[19] T. L. Saaty, "The analytic hierarchy process: planning," *Prior. Setting. Resour. Alloc. MacGraw-Hill, New York Int. B. Co.*, 1980.

[20] C. T. Ho, "Measuring bank operations performance: An approach based on Grey Relation Analysis," *J. Oper. Res. Soc.*, 2006, doi: 10.1057/palgrave.jors.2601985.

[21] Y. Kuo, T. Yang, and G. W. Huang, "The use of grey relational analysis in solving multiple attribute decision-making problems," *Comput. Ind. Eng.*, 2008, doi: 10.1016/j.cie.2007.12.002.

[22] G. Xu, Y. ping Yang, S. yuan Lu, L. Li, and X. Song, "Comprehensive evaluation of coal-fired power plants based on grey relational analysis and analytic hierarchy process," *Energy Policy*, 2011, doi: 10.1016/j.enpol.2011.01.054.

[23] X.-C. Xiao, X.-Q. Wang, K.-Y. Fu, and Y.-J. Zhao, "Grey Relational Analysis on Factors of the Quality of Web Service," *Phys. Procedia*, 2012, doi: 10.1016/j.phpro.2012.05.313.

[24] G. D. Li, D. Yamaguchi, and M. Nagai, "A grey-based decision-making approach to the supplier selection problem," *Math. Comput. Model.*, 2007, doi: 10.1016/j.mcm.2006.11.021.