*Environ Res Tec, Vol. 8, Issue. 1, pp. 139-151, March 2025*

**Environmental Research and Technology**
https://dergipark.org.tr/tr/pub/ert
DOI: https://10.35208/ert.1488726

**Research Article**

# Sustainable airline company selection using SWARA Weighted VIKOR and COPRAS methods

**Aybike Esra ŞAHİN*, Celil DURDAĞ, Fatma Betül BAĞLAN, Elif ARSLAN DİNÇ**

*Department of Logistics Management, İstanbul Esenyurt University Faculty of Economics, Administrative and Social Science, İstanbul, Türkiye*

## ARTICLE INFO

*Article history*
Received: 23 May 2024
Revised: 12 August 2024
Accepted: 13 August 2024

**Key words:**
Air transport; $CO_2$ emission; Energy consumption; European green deal; Multi-criteria decision making; Sustainable airlines

## ABSTRACT

Global climate crisis necessitates all countries to swiftly and agilely conduct their economic activities in accordance with green sensitivity and sustainability principles. The aviation sector, one of the industries most affected by socio-economic and socio-cultural changes worldwide, cannot avoid this trend. Consequently, significant studies exist in the literature on the effects of the global climate crisis and sustainability efforts in the aviation sector. This study aims to measure the approaches of the world's leading international air cargo companies to the 2030 and 2050 European Green Deal targets. Among the criteria weighted using the SWARA method are 'carbon dioxide emissions,' 'energy consumption,' 'employment,' and 'water consumption.' The results indicate that the most critical criterion for airline sustainability is reducing $CO_2$ emissions, followed by reducing energy consumption. Water consumption reduction ranks third, and employment ranks last in terms of importance. The study examines air cargo companies ranked in the top 10 globally by revenue and ranks them using the VIKOR and COPRAS methods. According to data from 2021, Korean Air, Turkish Airlines, and Cathay Pacific emerge as the top performers in sustainability among air cargo companies, while Cargolux and UPS lag behind others in their sustainability efforts when evaluated using VIKOR and COPRAS methods.

**Cite this article as:** Şahin AE, Durdağ C, Bağlan FB, Arslan Dinç E. Sustainable airline company selection using SWARA Weighted VIKOR and COPRAS methods. Environ Res Tec 2025;8(1)139-151.

## INTRODUCTION

In recent years, sustainability has become a widely discussed and examined topic both for individuals and businesses. Sustainability in supply chain management involves managing materials, information, and capital across the chain and fostering collaboration among businesses within the chain. It also aims to set goals for and achieve sustainable development in three dimensions defined by stakeholders and customer expectations [1].

The concept of sustainability fundamentally includes preserving today's conditions and ensuring equal opportunities for all individuals in society to meet their rights and needs, as well as providing equal conditions for future generations [2]. According to the definition by the World Commission on Environment and Development, sustainability means meeting the needs of current generations without compromising the ability of future generations to meet their own needs [3]. Sustainability comprises three components: society, environment, and economy [4]. For

***Corresponding author.**
*E-mail address: aesahin@gelisim.edu.tr

**The current affiliation of the author: Department of Logistics Management, İstanbul Gelişim University Faculty of Economics, Administrative and Social Sciences, İstanbul, Türkiye.*

social sustainability, governments need to implement equitable policies in education, health, security, transportation, etc. Issues such as air quality, waste management, noise, biodiversity conservation, and water resource conservation are examined to ensure environmental sustainability. Economic sustainability, on the other hand, requires studies supporting issues such as employment, economic growth, productivity, and efficiency. Enhancing environmental sustainability and raising awareness among all stakeholders are crucial for businesses operating in logistics, particularly in minimizing environmental damage in transportation. To achieve sustainability in aviation transportation, measures such as using Sustainable Aviation Fuels (SAF) derived from renewable or recyclable waste as alternatives to fossil fuels are taken to reduce carbon emissions, energy consumption, and water use. Without the participation of airports in the process, achieving sustainability in aviation is not possible, hence airports are recognized as 'green airports' aiming to reduce environmental pollution arising from their operations by fulfilling international criteria. Aviation transportation is particularly susceptible to both local and global fluctuations, leading airlines to adjust flight frequencies and schedules accordingly. Consequently, shifts in airlines' employment policies often culminate in workforce reductions.

Every decision leading to employment shortages globally creates serious problems. Problems arising in a strategic field such as aviation can pose greater risks for countries. Due to the significant impact of external environmental factors on aviation transportation levels, sustainability efforts have become mandatory for airline companies. This phenomenon can create negative impacts not only on job loss issues but also on many stakeholders in the aviation transportation sector. Sustainability efforts not only evaluate whether airline companies can survive from a management perspective but also assess them from perspectives of environmental protection, combating climate change, and green management.

In this study, the increasingly important concept of sustainability has been evaluated from the perspective of the strategic sector of aviation transportation. Prominent global airline cargo companies have been ranked in terms of sustainability using SWARA-weighted VIKOR and COPRAS analyses. Through these analyses, the top 10 airline cargo transportation companies worldwide have been subjected to performance evaluation within the context of the European Green Deal objectives. Thus, the sustainability levels of globally renowned airline companies and areas requiring sustainability improvements have been identified. In this context, the necessary criteria for sustainable and green airlines have been determined through a literature review. These criteria include carbon dioxide emissions, water consumption, employment, and energy consumption. The importance levels of these criteria were determined based on the opinions of 4 experts. Following the determination of criterion weights (importance levels), 10 airline companies were evaluated using VIKOR and COPRAS methods. The results can provide information to the sector and policymakers about the status of aviation transportation. The findings demonstrate how airline companies perform in critical areas such as carbon emissions, water consumption, employment policies, and energy use. This assessment serves as an important starting point for identifying improvement areas in the sector and encouraging sustainability efforts.

Furthermore, future studies should conduct more comprehensive assessments from a sustainability management perspective to examine how aviation transportation can contribute to achieving long-term sustainability goals. Research in this direction can play a critical role in strengthening the sustainability strategies of airline companies and aligning with global environmental targets.

## LITERATURE RESEARCH ON SUSTAINABILITY, GREEN LOGISTICS AND AIRLINE COMPANY SELECTION

Researchers have been working on green activities and sustainability for many years. Table 1 presents the literature review conducted between 2015–2024 and current studies on sustainability, green logistics, and airline company selection. Among these studies, especially the studies in which analyses were made using multi-criteria decision methods were discussed.

When examining Table 1, numerous studies focusing on green logistics, sustainability in transportation, and sustainable firm selection using multi-criteria decision-making methods are observed in the literature. Additionally, studies evaluating global airline companies from a sustainability perspective are also documented. However, no study applying the SWARA-VIKOR-COPRAS model has been encountered. This highlights the contribution of the current study in filling this gap in the literature. The insights generated by this model's results can offer notable predictions when compared with findings from different models.

## MATERIALS AND METHODS

In this study on Sustainable Airline Selection, the top 10 global air cargo companies were selected as the sample, aiming to identify the sustainable companies among them. The WATS+ 2021 report was used as a source for selecting the companies in question. Initially, a literature review was conducted to determine the criteria for a sustainable airline company. Aracı and Yüksel [20] calculated the sustainable added value in their study, aiming to consider all the social and environmental resources that a business uses and affects. Due to the scarcity of data published by companies in their sustainability reports, the $CO_2$ (greenhouse gas) emissions, energy use, water use, and the number of employees of the companies included in the sample were taken as sources, and calculations were made based on these criteria. In this study, the criteria required for the analysis are discussed through the sources used by Aracı and Yüksel [20] in their research. After defining the research problem, a method search was conducted to solve this problem, and it was determined that the SWARA-weighted VIKOR and COPRAS methods, which are multi-criteria decision-making methods, were appropriate.

**Table 1.** Studies on sustainability, green logistics, airline company selection (2015–2024)

| Author | Year | Title of the study | Subject of study | Analysis methods used |
|---|---|---|---|---|
| Sijin Wu, Marios Dominikos Kremantzi, Umair Tanveer, Shamaila Ishaq, Xianghan O'Dea, Hua Jin [5] | 2024 | Performance evaluation of the global airline industry under the impact of the COVID-19 pandemic: A dynamic network data envelopment analysis approach | The impact of the COVID-19 pandemic on the airline industry and analysis of the efficiency performance of international airline companies during this period | Dynamic DEA model |
| Gökhan Tanrıverdi, Rico Merkert, Çağlar Karamaşa, Veysi Asker [6] | 2023 | Using multi-criteria performance measurement models to evaluate the financial, operational and environmental sustainability of airlines | Examining the impact of the COVID-19 crisis on airline sustainability performance. | MEREC–CoCoSo/ Borda |
| Sukran Seker [7] | 2024 | Evaluation of agile attributes for low-cost carriers to achieve sustainable development using an integrated MCDM approach | Evaluating agile attributes for managing the operations of low-cost carriers (LCCs) in Türkiye | SWARA and MABAC |
| Thanh-Tuan Dang, Ngoc-Ai-Thy Nguyen, Van Thanh-Tien Nguyen and Le-Thanh-Hieu Dang [8] | 2022 | A Two-Stage Multi-Criteria Supplier Selection Model for Sustainable Automotive Supply Chain under Uncertainty | Selecting and evaluating a potential supplier based on their ability to adapt sustainably to the COVID-19 pandemic | SF-AHP, G-COPRAS |
| Kumari and Mishra [9] | 2020 | Multi-Criteria COPRAS Method Based On Parametric Measures For Intuitionistic Fuzzy Sets: Application Of Green Supplier Selection | Green supplier selection problem. | COPRAS |
| Kaya and Erginel [10] | 2020 | Futuristic Airport: A Sustainable Airport Design By Integrating Hesitant Fuzzy SWARA And Hesitant Fuzzy Sustainable Quality Function Deployment | Designing sustainable airports with environmental sensitivity. | Hesitant Fuzzy SWARA |
| Kutlu and Erçoşkun [11] | 2021 | Evaluation Of Logistic Firms In Türkiye On Green Logistics Applications | Green logistics practices of 17 companies | Comparison matrix |
| Semercioğlu and Özkoç [12] | 2019 | Social Choice Theory Supported By Analytical Hierarchy Process: Aircraft Charter Selection Process | Determining the criteria for which airline the three aircraft flying in medium and short distances should work in | AHP |
| Osintsev [13] | 2021 | Multi-Criteria Decision Making Methods In Green Logistics | Selection of green logistics methods and technologies | Fuzzy AHP, SAW, TOPSIS, PROMETHEE, COPRAS, ARAS, WASPAS, MAIRCA, |

**Table 1 (cont).** Studies on sustainability, green logistics, airline company selection (2015–2024)

| Author | Year | Title of the study | Subject of study | Analysis methods used |
|---|---|---|---|---|
| | | | | EDAS, MABAC, CODAS |
| Alkhatib and Migdadi [14] | 2021 | A Novel Technique For Evaluating And Ranking Green Airlines: Benchmarking-Base Comparison | Evaluating and ranking 20 green airways | DEMATEL, AHP, TOPSIS |
| Kuo et al. [15] | 2015 | Developing a Green Supplier Selection Model by Using the DANP with VIKOR | The evaluation of green suppliers in electronics companies according to seventeen criteria related to environmental and management systems under the Electronic Industry Citizenship Coalition's (EICC) Code of Conduct. | DEMATEL, ANP, VIKOR |
| Alharasees and Kale [16] | 2023 | Applying AHP for supplier selection in aviation: a multi-criteria decision-making approach | Examining the development of complex air transport systems in the aviation industry that can rapidly adapt to increasing demand while balancing reliability and performance, emphasizing the importance of quality measurements and assessing air transport supply-side quality across four groups of aviation professionals. | AHP |
| Kılkış and Kılkış [17] | 2017 | Benchmarking aircraft metabolism based on a Sustainable Airline Index | Comparing the aircraft metabolism of 16 airline companies and identify aspects related to sustainable aviation. | EFA |
| Durak and Yılmaz [18] | 2016 | Airline Selection Criteria At Air Cargo Transportation Industry | Determining the criteria influencing the selection of transportation services for air cargo transportation. | AHP |
| Elhmoud and Kutty [19]q | 2021 | Sustainability Assessment in Aviation Industry: A Mini-Review on the Tools, Models and Methods of Assessment | A small-scale literature review on various tools and methods used for sustainability assessment in the aviation industry. | AI, NN, DSS |

Multi-Criteria Decision Making (MCDM) is a scientific field that provides tools, models, and methodologies to effectively address decision problems. MCDM supports the decision-making process by enabling the analyst to compare and evaluate different actions/alternatives based on specific criteria, allowing the decision-maker to reach an efficient solution according to their preferences [21]. Among the multi-criteria decision-making methods, the VIKOR method defines a compromise ranking list, a compromise solution, and the decision-making stability intervals based on the weights provided by experts. It allows ranking and selection among alternatives in problems with conflicting criteria. The method ensures maximum group utility and minimum individual regret values and provides various ranking indices based on the closeness to the ideal solution. Therefore, the use of the VIKOR method was deemed appropriate for this study [22]. The COPRAS method, introduced into the literature by Zavadskas and colleagues in 1994, is a method whose reliability and accuracy have been acknowledged by many scholars. Today, it is used to solve a

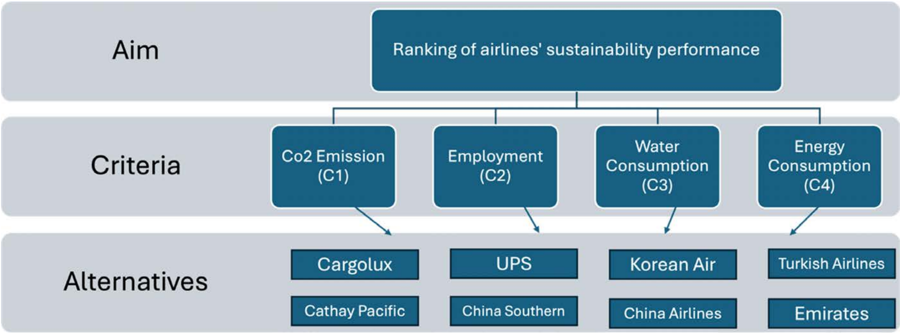


**Figure 1**. Model of the study.

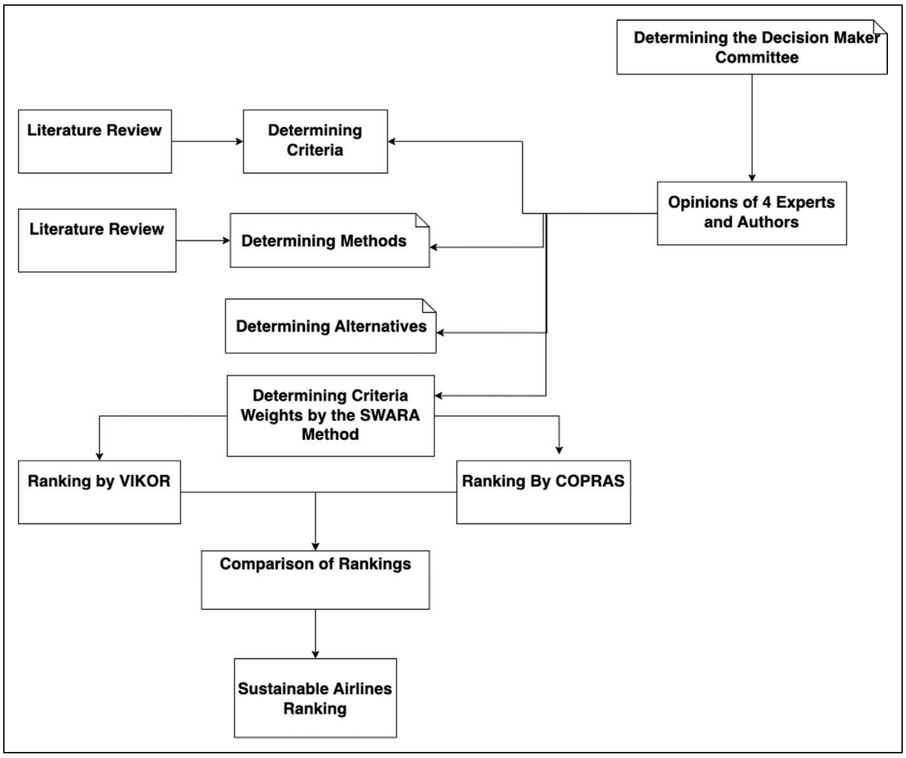


**Figure 2**. Flowchart depicting the decision-making process.

wide range of problems in various fields of engineering and management. One of the advantages of the method is the relatively short calculation stages and duration. To ensure the reliability of the research results, an additional method was required after the VIKOR method, and thus the COPRAS method was applied [23].

The criteria and alternative hierarchy discussed in the study are given in Figure 1.

The detailed flowchart of the research is depicted in Figure 2.

The methods used in the research, along with their mathematical steps, are explained in the below section.

### SWARA Method (Step-Wise Weight Assessment Ratio Analysis)

Step-Wise Weight Assessment Ratio Analysis is one of the frequently preferred criteria weighthing methods in solving MCDM problems. The SWARA method developed by Kersuliene, Zavadskas and Turksis [24] is an export-oriented method. Due to the fact that it requires subjective evaluations, decision-makers can determine their priorities within the framework of current conditions and thus play a more active role compared to other methods [25]. The method steps are as follows:

**Step 1:** The experts rank the criteria in order of importance, with the most important criterion first.

**Step 2:** Starting from the second criterion, i–1. criterion and i. criteria are compared and the relative importance value is calculated for the other criteria except the first criterion. It is found how important i–1. criteria are compared to i. criteria. When calculating this value, it uses a multiple of 0.05 and is expressed as $s_i$.

**Step 3:** Using Eq (1), the coefficient of ($k_i$) is calculated.

$$k_i = \begin{cases} 1 & i=1 \\ s_i + 1 & i>1 \end{cases} \tag{1}$$

**Step 4:** Using Eq (2), the corrected weight value ($q_i$) is calculated.

$$q_i = \begin{cases} 1 & i=1 \\ \frac{q_{i-1}}{k_i} & i>1 \end{cases} \tag{2}$$

**Step 5:** Using Eq (3), the criterion weight ($w_i$) is obtained.

$$w_i = \frac{q_i}{\sum_{i=1}^{n} q_i} \tag{3}$$

**Step 6:** If more than one decision maker is used in the solution of the problem, the final criterion weights are reached by taking the geometric mean of all $w_i$ values.

**VIKOR Method (Vise Kriterijumska Optimizacija I Kompromisno Resenje)**

VIKOR (Vise Kriterijumska Optimizacija I Kompromisno Resenje), translated into English as "Multi-Criteria Optimization and Compromise Solution", is a method used to rank multiple alternatives in multi-criteria decision making problems. It helps to determine the solution that can be closest to the ideal solution point by evaluating the alternatives on the basis of each criterion. The VIKOR method, which was first introduced by Opricović and Tzeng [26] is often preferred for selection and ranking in situations where there are conflicting criteria. The method steps are as follows:

**Step 1:** With the help of Eq (4) and Eq (5), the best ($f_i^*$) and worst ($f_i^-$) values are determined based on criteria. While determining these values, it is taken into account whether the criterion is benefit or cost criterion.

$$f_i^* = \underset{j}{max} f_{ij} \tag{4}$$

$$f_i^- = \underset{j}{min} f_{ij} \tag{5}$$

**Step 2:** Using Eq (6) and Eq (7), alternative-based $S_j$ and $R_j$ values are determined. Here $w_i$ are predetermined criteria weights.

$$S_j = \sum_{i=1}^{n} \frac{w_i(f_i^* - f_{ij})}{(f_i^* - f_i^-)} \tag{6}$$

$$R_j = max\left[\sum_{i=1}^{n} \frac{w_i(f_i^* - f_{ij})}{(f_i^* - f_i^-)}\right] \tag{7}$$

**Step 3:** Using Eq (8), $Q_j$ values are calculated for each alternative.

$$Q_j = \frac{v(S_j - S^*)}{(S^- - S^*)} + (1-v)\frac{(R_j - R^*)}{(R^- - R^*)} \tag{8}$$

In this section;

$$S^* = \underset{j}{min} S_j \tag{9}$$

$$S^- = \underset{j}{max} S_j \tag{10}$$

$$R^* = \underset{j}{min} R_j \tag{11}$$

$$R^- = \underset{j}{max} R_j \tag{12}$$

calculated using the formulas. $\underset{j}{min} S_j$ refers to choosing the largest group benefit, and $\underset{j}{min} R_j$ refers to choosing the smallest among the biggest personal regrets. The value v indicates the importance level for the strategy that provides the maximum group benefit, while the value (1–$v$) expresses the importance level of the minimum regret of the opponents. It is usually used as $v$=0.5.

**Step 4:** The calculated $S_j$, $R_j$ and $Q_j$ values are sorted. The alternative with the smallest $Q_j$ value is defined as the best alternative among the options. Two conditions must be met for the result obtained to be valid. These conditions are as follows;

**Condition 1:** This is the condition that involves proving that there is a significant difference between the best and the closest option. The mathematical representation of the relevant condition is given in Eq (13).

$$Q(P_2) - Q(P^1) \geq D(Q) \tag{13}$$

Here $P_1$ is the 1st best alternative with the least $Q$ value. $D(Q)$ is calculated with the formula in Eq (14);

$$D(Q) = \frac{1}{(j-1)} \tag{14}$$

If the number of alternatives (j) is less than 4, $D(Q)$=0.25 is taken.

**Condition 2:** For the obtained compromise solution to prove stable, the alternative $P_1$ with the best $Q$ value must have the best score in at least one of the $S$ and $R$ values.

If one of the two specified conditions is not met, the compromise solution set is suggested as follows:

If Condition 2 cannot be met, the condition in Eq (14) is sought by considering alternatives $P_1$ and $P_2$,

If Condition 1 cannot be met, $P_1, P_2, \dots, P_M$ alternatives are going to be considered.

$$Q(P_M) - Q(P_1) \geq D(Q) \tag{15}$$

Within the compromise solution set, sorting is done according to the $Q$ values. The best alternative is one with the minimum $Q$ value.

**COPRAS Method (Complex Proportional Assessment)**

The performance evaluations of M alternatives according to n criteria are assumed to be represented by a decision matrix X=$[x_{ij}]_{mxn}$, where $x_{ij}$ represents the rating of the *i–th* alternative on the *j–th* criterion.

The Eq (16) representing the decision matrix X formed with performance values $x_{ij}$ is expressed as follows [24]:

$$\boldsymbol{X = [x_{ij}]_{mxn}} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{12} & x_{22} & \cdots & x_{2n} \\ \vdots & \ddots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \; i = 1,2,3,\dots,m \text{ and } j = 1,2,3,\dots,n. \tag{16}$$

**Step 1:** Normalization and the creation of the normalized decision matrix: In the COPRAS method, the performance values $x_{ij}$ constituting the X decision matrix obtained through regularization are transformed into normalized performance values $\bar{x}_{ij}$ using;

$$\bar{x}_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \tag{17}$$

thus the normalized decision matrix $\overline{X}$ is represented by;

$$\bar{X} = [\bar{x}_{ij}]_{mxn} = \begin{bmatrix} \bar{x}_{11} & \bar{x}_{12} & \cdots & \bar{x}_{1n} \\ \bar{x}_{12} & \bar{x}_{22} & \cdots & \bar{x}_{2n} \\ \vdots & \ddots & \ddots & \vdots \\ \bar{x}_{m1} & \bar{x}_{m2} & \cdots & \bar{x}_{mn} \end{bmatrix} \; i = 1,2,3,\dots,m \text{ and } j = 1,2,3,\dots,n. \tag{18}$$

**Table 2.** Calculations of criterion (CR) importance values of decision maker 1

| CR | Importance level | $s_i$ | $k_i$ | $q_i$ | $w_i$ |
|---|---|---|---|---|---|
| C1 | 1 | | 1 | 1 | 0.4 |
| C3 | 2 | 0.6 | 1.6 | 0.6 | 0.2 |
| C4 | 3 | 0.5 | 1.5 | 0.4 | 0.1 |
| C2 | 4 | 0.3 | 1.3 | 0.3 | 0.1 |

**Table 3.** Calculations of criterion (CR) importance values of decision maker 2

| CR | Importance level | $s_i$ | $k_i$ | $q_i$ | $w_i$ |
|---|---|---|---|---|---|
| C4 | 1 | | 1 | 1 | 0.3 |
| C1 | 2 | 0.3 | 1.3 | 0.7 | 0.3 |
| C3 | 3 | 0.5 | 1.5 | 0.5 | 0.2 |
| C2 | 4 | 0.9 | 1.9 | 0.2 | 0.1 |

**Step 2:** Weighting and the creation of the weighted normalized decision matrix: The normalized performance values $\bar{x}_{ij}$ constituting the $\overline{X}$ normalized decision matrix are transformed into weighted normalized performance values $\hat{x}_{ij}$ using,

$$\hat{x}_{ij} = \bar{x}_{ij}.w_j \tag{19}$$

As a result, the weighted normalized decision matrix $\hat{X}$ is represented by

$$\hat{X} = [\hat{x}_{ij}]_{mxn} = \begin{bmatrix} \hat{x}_{11} & \hat{x}_{12} & \cdots & \hat{x}_{1n} \\ \hat{x}_{12} & \hat{x}_{22} & \cdots & \hat{x}_{2n} \\ \vdots & \ddots & \ddots & \vdots \\ \hat{x}_{m1} & \hat{x}_{m2} & \cdots & \hat{x}_{mn} \end{bmatrix} \; i = 1,2,3,\ldots,m \text{ and } j = 1,2,3,\ldots,n. \tag{20}$$

**Step 3:** Calculation of total weighted normalized values based on benefit and cost criteria: Criterion-based total weighted normalized values, considering the benefit or cost nature of the criterion, are calculated using;

$$S_{+i} = \sum_{j=1}^{k} \hat{x}_{+ij} \; i = 1,2,3,\ldots,m \text{ and } j = 1,2,3,\ldots,n \tag{21}$$

$$S_{-i} = \sum_{j=k+1}^{n} \hat{x}_{-ij} \; i = 1,2,3,\ldots,m \text{ and } j = k+1,k+2,k+3,\ldots,n \tag{22}$$

where $S_{+i}$ represents the sum of benefit criteria and $S_{-i}$ represents the sum of cost criteria. The weighted normalized performance values $\hat{x}_{+ij}$ and $\hat{x}_{-ij}$ appearing in the equations respectively indicate performance values with benefit and cost criteria.

**Step 4:** Calculation of relative importance values:

The value $Q_i$ to indicate the relative importance value of the *i–th* alternative will be determined using,

$$Q_i = S_{+i} + \frac{S_{-min} \cdot \sum_{i=1}^{m} S_{-i}}{S_{-i} \cdot \sum_{i=1}^{m} \left(\frac{S_{-min}}{S_{-i}}\right)} \; i = 1,2,3,\ldots,m \tag{23}$$

calculated using the parameters $S_{+i}$ and $S_{-i}$. The parameter $S_{-min}$ in the equation represents the minimum value among the $S_{-i}$) values.

**Step 5:** Calculation of performance index values:

The value $P_i$, representing the performance index value of the *i–th* alternative, is calculated using,

**Table 4.** Calculations of criterion (CR) importance values of decision maker 3

| CR | Importance level | $s_i$ | $k_i$ | $q_i$ | $w_i$ |
|---|---|---|---|---|---|
| C2 | 1 | | 1 | 1 | 0.4 |
| C1 | 2 | 0.8 | 1.8 | 0.5 | 0.2 |
| C3 | 3 | 0.7 | 1.7 | 0,3 | 0.1 |
| C4 | 4 | 0.9 | 1.9 | 0.1 | 0.08 |

**Table 5.** Calculations of criterion (CR) importance values of decision maker 4

| CR | Importance level | $s_i$ | $k_i$ | $q_i$ | $w_i$ |
|---|---|---|---|---|---|
| C1 | 1 | | 1 | 1 | 0.4 |
| C4 | 2 | 0.9 | 1.9 | 0.5 | 0.2 |
| C3 | 3 | 0.5 | 1.5 | 0.3 | 0.1 |
| C2 | 4 | 0.1 | 1.1 | 0.3 | 0.14 |

**Table 6.** Criterion (CR) weights obtained from the SWARA method

| CR | DM-1 | DM-2 | DM-3 | DM-4 | Final $w_i$ | Norm.final $w_i$ | Rank |
|---|---|---|---|---|---|---|---|
| C1 | 0.42 | 0.30 | 0.27 | 0.45 | 0.35 | 0.38 | 1 |
| C2 | 0.13 | 0.10 | 0.48 | 0.14 | 0.17 | 0.19 | 4 |
| C3 | 0.26 | 0.20 | 0.15 | 0.15 | 0.19 | 0.20 | 3 |
| C4 | 0.17 | 0.39 | 0.08 | 0.23 | 0.19 | 0.21 | 2 |
| Total | 0.19 | 1 | | | | | |

$$P_i = \left[\frac{Q_i}{Q_{max}}\right].100\% \; i = 1,2,3,\ldots,m. \tag{24}$$

**Step 6:** Evaluation of alternatives:

After completing all calculation steps, the obtained $P_i$ values are sorted in descending order to obtain the preference ranking of alternatives.

## FINDINGS

In this section, the analysis results have been interpreted in detail.

### Determination of Criteria Weights

2 academicians and 2 private sector employees were included in the research for the expert opinions required for the application. Decision makers were asked to rank the criteria according to their importance and give their $s_i$ values. As a result of the $s_i$ values obtained, $k_i$ $q_i$ and $w_i$ values were calculated for each decision maker by using Eqs (1–3). The criteria weights calculated on the basis of the decision maker are given in Table 2, Table 3, Table 4 and Table 5.

Since there is more than one decision maker, after the criterion weights ($w_i$) were determined on the basis of the decision maker, the final criterion weights were reached

**Table 7.** Data on alternatives

| Criteria/alternatives | $Co_2$ emission (tonne) (C1) | Employment (C2) | Water consumption ($m^3$) (C3) | Energy consumption (GJ) (C4) |
|---|---|---|---|---|
| Cargolux [27] | 158,191 | 83 | 313 | 2,841 |
| UPS [28] | 119,827 | 1,855 | 20,000 | 887,356 |
| Korean Air [29] | 58,149 | 122 | 3,574 | 7,966 |
| Turkish Airlines [30] | 44,842 | 75 | 690 | 506,289 |
| China Airlines [31] | 68,548 | 127 | 1,571 | 1,014,468 |
| Emirates [32] | 71,773 | 140 | 9,665 | 994,062 |
| Cathay Pacific [33] | 25,520 | 93 | 44,958 | 358,601 |
| China Southern [34] | 21,918 | 112 | 519,566 | 299,898 |
| $W_j$ | 0.39 | 0.2 | 0.2 | 0.21 |

**Table 8.** Best and worst values of criteria (CR)

| CR | C1 | C2 | C3 | C4 |
|---|---|---|---|---|
| $f_i^*$ | 21,918 | 1,855 | 313 | 2.841 |
| $f_i^-$ | 158,191 | 75 | 519,566 | 1,014,468 |

by taking the geometric mean of all $w_i$ values. The criterion weight values to be used in VIKOR and COPRAS were obtained by performing normalization on the final weights obtained by the SWARA method. Information on criterion weights is given in Table 6.

According to the results of the SWARA analysis, the most crucial criterion for airlines to achieve sustainability is reducing $CO_2$ emissions, followed by reducing energy consumption in second place and reducing water consumption in third. Employment ranks as the fourth criterion. These findings highlight the importance of reducing $CO_2$ emissions. (Fig. 3).

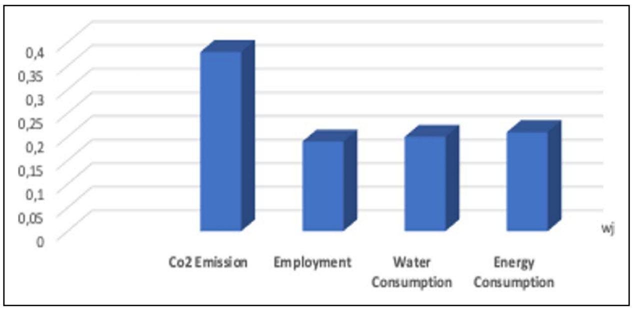


**Figure 3**. Ranking criteria by their level of importance.

**Evaluation of Alternatives**

The research utilized data sourced from the 2021 sustainability reports of airline companies. Due to incomplete data availability at the time, FedEx and Qatar Airways, both ranked in the global top 10, were excluded from consideration. Company metrics were normalized based on fleet size to ensure accurate comparative analysis. For instance, Cargolux, with 30 fleets, was adjusted relative to Turkish Airlines, which operates 370 fleets. These normalized values were tabulated to ensure equitable assessment across criteria, as detailed in Table 7.

With the help of Eqs (4–5), criteria-based best ($f_i^*$) and worst ($f_i^-$) values were determined and given in Table 8.

The weighted decision matrix is given in Table 9.

Alternative-based $S_j$ and $R_j$ values were determined using Eqs (6–7). Then, using Eq (8), $Q_j$ values were calculated for each alternative. In Eq (8) the "v" value is taken as 0.5. The $S_j$, $R_j$ and $Q_j$ values of the alternatives are given in Table 10.

**Table 9.** Weighted decision matrix

| Criteria/alternatives | $Co_2$ emission (tonne) (C1) | Employment (C2) | Water consumption ($m^3$) (C3) | Energy consumption (GJ) (C4) |
|---|---|---|---|---|
| Cargolux [27] | 0.390 | 0.001 | 0.000 | 0.000 |
| UPS [28] | 0.280 | 0.210 | 0.008 | 0.175 |
| Korean Air [29] | 0.104 | 0.006 | 0.001 | 0.001 |
| Turkish Airlines [30] | 0.066 | 0.000 | 0.000 | 0.100 |
| China Airlines [31] | 0.133 | 0.006 | 0.000 | 0.200 |
| Emirates [32] | 0.143 | 0.008 | 0.004 | 0.196 |
| Cathay Pacific [33] | 0.010 | 0.002 | 0.017 | 0.070 |
| China Southern [34] | 0.000 | 0.004 | 0.200 | 0.059 |

**Table 10.** $S_j$ and $R_j$ values of alternatives

| Alternatives | $S_j$ | $R_j$ |
|---|---|---|
| Cargolux [27] | 0.391 | 0.390 |
| UPS [28] | 0.671 | 0.280 |
| Korean Air [29] | 0.111 | 0.104 |
| Turkish Airlines [30] | 0.170 | 0.105 |
| China Airlines [31] | 0.350 | 0.210 |
| Emirates [32] | 0.359 | 0.206 |
| Cathay Pacific [33] | 0.103 | 0.074 |
| China Southern [34] | 0.266 | 0.200 |
| Min | 0.103 | 0.074 |
| Max | 0.671 | 0.390 |

The $Q_j$ values of alternatives are given in Table 11. The value of DQ = 0.143 was calculated.

By obtaining the Q(a") - Q (a') ≥ DQ values, the values in Table 12 were found.

Obtained $Q_j$ values are ordered from smallest to largest and the alternative with the smallest value is selected as the best alternative. Condition 1 and Condition 2 were examined in order to ensure the validity of the obtained ranking.

**Condition 1:** $Q(P_2)–Q(P_1)≥D(Q)$

$Q(P_2)$-$Q(P_1)$= 0.05 – 0 = 0.05

$D(Q)=1\backslash((j–1))$ = 1 / (8 – 1) = 0.143

0.05 ≤ 0.143

**Condition 2:** The $P_1$ alternative with the best Q value must have achieved the best score in at least one of the $S$ and $R$ values.

$min_S$=0.1

$S_{Cathay\ Pacific}$=0.1

As a result of the examination, it was seen that while Condition 2 was met, Condition 1 was not. For this reason, the condition in Eq (13) is discussed. When Table 13 is examined, it is seen that this condition is met in the 4th alternative.

Accordingly, Alternative 1, Alternative 2 and Alternative 3 were determined as compromise solutions. The final ranking of the alternatives is given in Table 14.

Using the same data, COPRAS analysis has been conducted. Data has been normalized using Eq (17). In Table 15, the first step of the COPRAS method has been applied and is shown as the normalized decision matrix.

Using the criteria weights obtained through the SWARA method, calculations were performed with Eq (18) to create the weighted normalized decision matrix. Table 16 presents the weighted normalized decision matrix which is the next step in the COPRAS method.

The results have been obtained using Eqs (21-24), and are shown in Table 17.

According to COPRAS results, sustainability rankings among alternatives show significant differences. China Southern ranks first with a $Q_i$ value of 0,350 and a $P_i$ value of 100. Cathay Pacific follows closely in second place with $Q_i$ of 0,176 and $P_i$ of 50,134. Korean Air secures the third position with $Q_i$ of 0,141 and $P_i$ of 40,182. Turkish Airlines and Emirates occupy the fourth and fifth positions respectively, with lower $Q_i$ and $P_i$ values. UPS, China Airlines, and Cargolux rank lower, indicating comparatively lower sustainability performance based on their $Q_i$ and $P_i$ values. These findings provide important insights into how sustainability efforts vary among different companies in the air cargo transportation sector and highlight areas for improvement.

Table 18 allows for the comparison of the ranking results given by both methods.

According to the findings of the COPRAS method, China Southern Airlines holds the 1st position, whereas in the VIKOR results, it occupies the 4th position. Cathay Pacific is ranked 2nd by COPRAS, whereas it claims the top spot according to VIKOR. Korean Air secures the 3rd position in COPRAS and also ranks 1st in VIKOR. Turkish Airlines ranks 4th in COPRAS and 1st in VIKOR. Following these, China Airlines holds the 5th position in one method and the 6th in the other, while Emirates similarly ranks 6th in one and 5th in the other. The rankings of the remaining companies remain consistent across both methods (Fig. 4).

**Table 11.** $Q_j$ values of alternatives

| Alternatives | $Q_j$=0 | $Q_j$=0.25 | $Q_j$=0.5 | $Q_j$=0.75 | $Q_j$=1 |
|---|---|---|---|---|---|
| Cargolux [27] | 1.000 | 0.877 | 0.753 | 0.630 | 0.506 |
| UPS [28] | 0.653 | 0.740 | 0.826 | 0.913 | 1.000 |
| Korean Air [29] | 0.094 | 0.074 | 0.054 | 0.034 | 0.014 |
| Turkish Airlines [30] | 0.097 | 0.102 | 0.107 | 0.113 | 0.118 |
| China Airlines [31] | 0.431 | 0.431 | 0.432 | 0.433 | 0.434 |
| Emirates [32] | 0.417 | 0.426 | 0.434 | 0.442 | 0.451 |
| Cathay Pacific [33] | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| China Southern [34] | 0.399 | 0.371 | 0.342 | 0.314 | 0.286 |

**Table 12.** Ranking of alternatives

| Alternatives | $Q_j$=0.5 | Rankings |
|---|---|---|
| Cargolux [27] | 0.753 | 7 |
| UPS [28] | 0.826 | 8 |
| Korean Air [29] | 0.054 | 2 |
| Turkish Airlines [30] | 0.107 | 3 |
| China Airlines [31] | 0.432 | 5 |
| Emirates [32] | 0.434 | 6 |
| Cathay Pacific [33] | 0.000 | 1 |
| China Southern [34] | 0.342 | 4 |

**Table 13.** Finding the set of compromise solutions

| $Q(P_M) - Q(P_1)$ | ≥D(Q) | $Q(P_M) - Q(P_1)$ |
|---|---|---|
| 0.05 | ≤DQ | P2-P1 |
| 0.1 | ≤DQ | P3-P1 |
| 0.35 | ≥DQ | P4-P1 |
| 0.43 | ≥DQ | P5-P1 |
| 0.44 | ≥DQ | P6-P1 |
| 0.75 | ≥DQ | P7-P1 |
| 0.82 | ≥DQ | P8-P1 |

**Table 14.** Final ranking of alternatives

| Alternatives | Ranking |
|---|---|
| Cargolux [27] | 1 |
| UPS [28] | 1 |
| Korean Air [29] | 1 |
| Turkish Airlines [30] | 4 |
| China Airlines [31] | 5 |
| Emirates [32] | 6 |
| Cathay Pacific [33] | 7 |
| China Southern [34] | 8 |

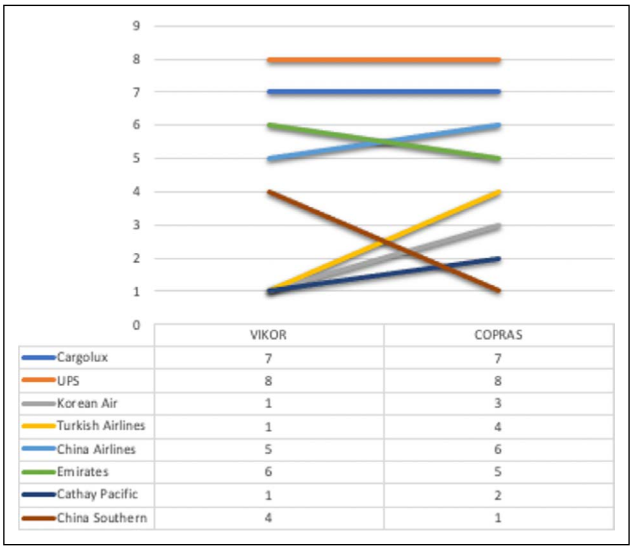


**Figure 4**. Comparing the results of two methods.

**Table 15.** Normalized decision matrix table

| Alternatives | C1 | C2 | C3 | C4 |
|---|---|---|---|---|
| Cargolux [27] | 0.278 | 0.032 | 0.001 | 0.001 |
| UPS [28] | 0.211 | 0.712 | 0.033 | 0.218 |
| Korean Air [29] | 0.102 | 0.047 | 0.006 | 0.002 |
| Turkish Airlines [30] | 0.079 | 0.029 | 0.001 | 0.124 |
| China Airlines [31] | 0.121 | 0.049 | 0.003 | 0.249 |
| Emirates [32] | 0.126 | 0.054 | 0.016 | 0.244 |
| Cathay Pacific [33] | 0.045 | 0.036 | 0.075 | 0.088 |
| China Southern [34] | 0.039 | 0.043 | 0.865 | 0.074 |

**Table 16.** Weighted normalized decision matrix

| | Min | Min | Max | Min |
|---|---|---|---|---|
| | 0.39 | 0.20 | 0.20 | 0.21 |
| **Alternatives** | **C1** | **C2** | **C3** | **C4** |
| Cargolux [27] | 0,108 | 0,006 | 0,000 | 0,000 |
| UPS [28] | 0,082 | 0,142 | 0,007 | 0,046 |
| Korean Air [29] | 0,040 | 0,009 | 0,001 | 0,000 |
| Turkish Airlines [30] | 0,031 | 0,006 | 0,000 | 0,026 |
| China Airlines [31] | 0,047 | 0,010 | 0,001 | 0,052 |
| Emirates [32] | 0,049 | 0,011 | 0,003 | 0,051 |
| Cathay Pacific [33] | 0,017 | 0,007 | 0,015 | 0,018 |
| China Southern [34] | 0,015 | 0,009 | 0,173 | 0,015 |

**Table 17.** Relative importance and index values

| Alternatives | $S_{+i}$ | $S_{-i}$ | $Q_i$ | $P_i$ | Ranking |
|---|---|---|---|---|---|
| Cargolux [27] | 0,000 | 0,115 | 0,060 | 17,231 | 7 |
| UPS [28] | 0,007 | 0,270 | 0,032 | 9,221 | 8 |
| Korean Air [29] | 0,001 | 0,050 | 0,141 | 40,182 | 3 |
| Turkish Airlines [30] | 0,000 | 0,063 | 0,111 | 31,653 | 4 |
| China Airlines [31] | 0,001 | 0,109 | 0,064 | 18,283 | 6 |
| Emirates [32] | 0,003 | 0,111 | 0,066 | 18,701 | 5 |
| Cathay Pacific [33] | 0,015 | 0,043 | 0,176 | 50,134 | 2 |
| China Southern [34] | 0,173 | 0,039 | 0,350 | 100,000 | 1 |

**Table 18.** Comparison of rankings for both methods

| Alternatives | VIKOR | COPRAS |
|---|---|---|
| Cargolux [27] | 7 | 7 |
| UPS [28] | 8 | 8 |
| Korean Air [29] | 1 | 3 |
| Turkish Airlines [30] | 1 | 4 |
| China Airlines [31] | 5 | 6 |
| Emirates [32] | 6 | 5 |
| Cathay Pacific [33] | 1 | 2 |
| China Southern [34] | 4 | 1 |

## CONCLUSION

All commercial activities carried out on a global scale primarily shape themselves through short-term effects. Although its effects are on the way of fading, the COVID-19 pandemic and the Russia-Ukraine War, are the most recent examples. On the other hand, the fact that all companies that will struggle to survive in global competition will be preferred for the medium and long term will be largely decisive if they have maximized their sustainability with green activities.

In light of this reality, the study aimed to choose a sustainable company among the top 10 airline cargo companies according to the CTK (Cargo Ton-Km) published in the WATS+ (World Air Transport Statistics) report [35]. The data used in the analysis of the research were obtained from the companies' 2021 sustainability reports. Since all of the 2022 sustainability reports have not been published yet, it has been decided to use the data for 2021. For this reason, two companies that did not have a sustainability report were excluded from the study. Based on the SWARA analysis findings, the top priority for airlines in achieving sustainability is the reduction of $CO_2$ emissions, followed by decreasing energy consumption in second place and minimizing water consumption in third. Employment is ranked fourth among the criteria. These results underscore the critical importance of $CO_2$ emission reduction efforts for airlines. The findings of the VIKOR method indicate a compromise cluster for selecting the most sustainable company among 8 alternatives (airline companies). In this cluster, 3 airline companies—Cathay Pacific, Korean Airlines, and Turkish Airlines—were identified as a compromise solution. According to the results of the COPRAS method, China Southern, Cathay Pacific, and Korean Air were found to be at the forefront. In both results, UPS company ranked the lowest. These findings aimed to provide information about the sustainability efforts of companies in 2021 if the top 10 airline companies in the world ranking prepared by IATA were to be re-ranked in terms of sustainability.

The Turkish aviation sector also does not show a different structure from the general aviation trends in the world. The negative developments experienced in our country, mainly due to the economic and then the epidemic, have adversely affected the air transport sector. In this process, it was observed that some airline companies ended their activities, while some airline companies had to go to operational restrictions. The actors that make up the Turkish aviation sector, as well as the aviation actors of other countries, have gained more attention in terms of sustainability criteria, especially in their international activities. The ranking of Turkish Airlines in our research also clearly reveals that this issue should be addressed.

The results of this study will demonstrate the sustainability efforts of global airlines based on 2021 data. Future research could be updated to enable time series analysis, allowing for a more comprehensive understanding of sustainability trends over the years. By comparing future studies with the 2021 data, it will be possible to assess the progress or regression of the companies in terms of their sustainability initiatives.

## LIMITATIONS AND FURTHER RESEARCH

The study has several limitations. One of the limitations of this research is the difficulty in accessing data. The availability of sufficient data on sustainability index criteria such as noise pollution, waste management, social responsibility projects, natural resource use, employee rights and occupational safety, diversity and inclusion, education, and development depends on their inclusion in sustainability reports. Increasing the number of these criteria could broaden the scope of the research. In future studies, it may be suggested to create a multi-criteria decision-making model using fuzzy logic. For instance, criteria with data that are not precisely measurable or that rely on subjective assessments, such as noise pollution, social responsibility projects, or diversity and inclusion, can be more effectively analyzed using fuzzy logic. This approach can enable decision-making processes to be conducted more comprehensively and accurately, allowing for more precise ranking and evaluation of sustainability performances.

The SWARA method was used for weighting criteria in the study. SWARA method, being a subjective approach, relies on the personal experience and knowledge of experts. In future studies, it can be combined with an objective weighting method to recalculate with new weights. Data beyond what is disclosed in sustainability reports could not be accessed. With obtaining more data, the study can be expanded by considering different criteria. The criteria were weighted using the SWARA method, and a model was subsequently constructed using the VIKOR method to rank the companies accordingly. However, to ensure reliability, an additional method, the COPRAS method, was employed. This step was taken to facilitate sensitivity analysis and establish a more robust foundation for decision-making. Through sensitivity analysis, the aim was to compare the outcomes derived from different methodologies, thereby providing decision-makers with more precise insights.

In future scientific studies, it would be appropriate to evaluate the Turkish aviation industry on a firm basis within the framework of sustainability. Thus, the current situation of our country's aviation industry in terms of sustainability will be determined. It would be beneficial to carry out similar studies for different types of transportation both in the world and in our country. In addition, ranking the highways and seaports in terms of sustainability will be another research topic.

## DATA AVAILABILITY STATEMENT

The author confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

## CONFLICT OF INTEREST

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

## USE OF AI FOR WRITING ASSISTANCE

Not declared.

## ETHICS

There are no ethical issues with the publication of this manuscript.

## REFERENCES


[1] E. Yontar "Challenges, threats and advantages of using blockchain technology in the framework of sustainability of the logistics sector," Turkish Journal of Engineering, Vol. 7(3), pp. 186–195, 2023. [CrossRef]

[2] C. Altuntaş, and D. Türker, "Sürdürülebilir tedarik zincirleri: Sürdürülebilirlik raporlarının içerik analizi," Dokuz Eylul University The Journal of Graduate School of Social Sciences, Vol. 14(3), pp. 39–64, 2012.

[3] E. Alpman, and A. Y. Göğüş, "Havacılıkta sürdürülebilir gelişme göstergeleri," Journal of Sustainable Aviation Researches, Vol. 2(1), pp. 1–11. [CrossRef]

[4] O. Çetin, and A. D. Sain, "Lojistik Sektöründe Sürdürülebilirlik Uygulamaları," IV. International Caucasus-Central Asia Foreign Trade and Logistics Congress, Didim/AYDIN. 2018, 7-8 September. Available at: https://ulk.ist/media/kitap/IV-UKO-DTLK/lojistik-sektorunde-surdurulebilirlik-uygulamalari.pdf Accessed on Feb 26, 2025.

[5] S. Wu, M. D. Kremantzis, U. Tanveer, S. Ishaq, X. O'Dea, and H. Jin, "Performance evaluation of the global airline industry under the impact of the COVID-19 pandemic: A dynamic network data envelopment analysis approach," Journal of Air Transport Management, Vol. 118, Article 102597, 2024. [CrossRef]

[6] G. Tanrıverdi, R. Merkert, Ç. Karamaşa, and V. Asker, "Using multi-criteria performance measurement models to evaluate the financial, operational and environmental sustainability of airlines," Journal of Air Transport Management, Vol. 112, Article 102456, 2023. [CrossRef]

[7] S. Seker, "Evaluation of agile attributes for low-cost carriers to achieve sustainable development using an integrated MCDM approach" Management Decision, 2024. [Epub ahead of print]. https://doi.org/10.1108/MD-10-2023-1896 [CrossRef]

[8] T. T. Dang, N. A. T. Nguyen, V. T. T. Nguyen, and L. T. H. Dang, "A two-stage multi-criteria supplier selection model for sustainable automotive supply chain under uncertainty," Axioms, Vol. 11, Article 228, 2022. [CrossRef]

[9] R. Kumari, and A. R. Mishra, "Multi-criteria COPRAS method based on parametric measures for intuitionistic fuzzy sets: application of green supplier selection". Iranian Journal of Science and Technology, Transactions of Electrical Engineering, Vol. 44, pp. 1645–1662, 2020. [CrossRef]

[10] S. Kaya, and N. Erginel, "Futuristic airport: A sustainable airport design by integrating hesitant fuzzy SWARA and hesitant fuzzy sustainable quality function deployment," Journal of Cleaner Production, Vol. 275, pp. 1–15, 2020. [CrossRef]

[11] B. H. Kutlu, and Ö. Erçoşkun, "Türkiye'deki Lojistik Firmalarının Yeşil Lojistik Uygulamaları Üzerinden Değerlendirmesi," Eksen Journal of Dokuz Eylül University Faculty of Architecture, Vol. 2(1), pp. 52–71, 2021.

[12] H. Semercioğlu, and H. Özkoç, "Analitik Hiyerarşi Proses İle Desteklenmiş Sosyal Seçim Teorisi: Havayollarında Uçak Süreci," Journal of Social Sciences and Humanities Researcher, Vol. 20(44), pp. 67–92, 2019.

[13] N. Osintsev, "Multi-criteria decision-making methods in green logistics," World of Transport an Transportation, Vol. 19(5), pp. 231–240, 2021. [CrossRef]

[14] S. F. Alkhatib, and Y. K. A. A. Migdadi, "A novel technique for evaluating and ranking green airlines: Benchmarking-base comparison," Management of Environmental Quality, Vol. 32(2), pp. 210–226, 2021. [CrossRef]

[15] T. C. Kuo, C. W. Hsu, J. Y. Li, "Developing a green supplier selection model by using the DANP with VIKOR." Sustainability, Vol. 7, pp. 1661–1689, 2015. [CrossRef]

[16] O. Alharasees, and U. Kale, "Applying AHP for supplier selection in aviation: a multi-criteria decision-making approach," International Journal of Sustainable Aviation, 9(4), pp. 293–313, 2023. [CrossRef]

[17] Ş. Kılkış, and Ş. Kılkış, "Benchmarking aircraft metabolism based on a Sustainable Airline Index," Journal of Cleaner Production, Vol. 167, pp. 1068–1083, 2017. [CrossRef]

[18] M. Ş. Durak, and A. K. Yilmaz, "Airline selection criteria at air cargo transportation industry," Transport & Logistics: the International Journal, Vol. 16, Article 40, 2016.

[19] E. R. Elhmoud, A. A. Kutty, "Sustainability Assessment in Aviation Industry: A Mini- Review on the Tools, Models and Methods of Assessment." 2nd African International Conference on Industrial Engineering and Operations Management Harare, Zimbabwe, 7-10 December, 2021.

[20] H. Aracı, and F. Yüksel, "Sürdürülebilirlik Performansinin Ölçülmesi: Bist Sürdürülebilirlik Endeksindeki İşletmelerin Sürdürülebilir Katma Değerinin Hesaplanması." International Journal of Management Economics and Business, Suppl 16, pp. 786–801, 2016. [CrossRef]

[21] D. I. Stavrou, E. Y. Siskos, N. P. Ventikos, and J. E. Psarras, "Robust Evaluation of Risks in Ship-to-Ship Transfer Operations: Application of the STOCHASTIC UTA Multicriteria Decision Support Method" PTW Lee and Z. Yang (Eds.), Multi-Criteria Decision Making in Maritime Studies and Logistics: Applications and Cases, Springer, 2018. [CrossRef]

[22] M. Kabak, and B. Erdebilli. "Bulanik Cok Kriterli Karar Verme Yöntemleri: MS Excel ve Software Cözümlü Uygulamalar," Nobel Akademik Yayincilik, 2021.

[23] H. Altın, "Karar verme sürecinde COPRAS yöntemi uygulaması," Ekonomi, İşletme ve Maliye Araştırmaları Dergisi, Vol. 3(2), pp. 136–155, 2021. [CrossRef]

[24] V. Kersuliene, EK Zavadskas, and Z. Turskis, "Selection of rational dispute resolution method by applying new step-wise weight assessment ratio analysis (SWARA)," Journal of Business Economics and Management, Vol. 11(2), pp. 243-258, 2010. [CrossRef]

[25] H. S. Zolfani, and J. Saparauskas, "New application of SWARA method in prioritizing sustainability assessment indicators of energy system," Engineering Economics, Vol. 24(5), pp. 408-414, 2013. [CrossRef]
[26] S. Opricović, and G. H. Tzeng, "Compromise solution by MCDM methods: A comparative analysis of VIKOR and TOPSIS." European Journal of Operational Research, Vol. 156(2), pp. 445–455, 2004. [CrossRef]
[27] Cargolux, "Corporate Social Responsibility," 2021. Available at: https://www.cargolux.com/media/xogebwih/csrreport2021.pdf Accessed Jul 10, 2023.
[28] UPS GRI, "Global Reporting Initiative," 2021. Available at: https://about.ups.com/content/dam/upsstories/assets/reporting/sustainability-2021/2021%20UPS%20GRI%20Report.pdf Accessed Jul 10, 2023.
[29] Korean Air, "ESG Report," 2021. Available at: https://www.koreanair.com/content/dam/koreanair/ko/footer/about-us/sustainable-management/report/2021_Korean%20Air%20ESG%20Report_en.pdf Accessed Jul 10, 2023.
[30] Turkish Airlines, "Sustainability Report," 2021. Available at: https://investor.turkishairlines.com/documents/sustainability/turkish-airlines-sustainability-report-2021.pdf Accessed Jun 12, 2023.
[31] China Airlines, "Corporate Sustainability Report," 2021. Available at: https://calec.china-airlines.com/csr/en/download/2021/2021-en-CSR.pdf Accessed Jun 11, 2023.
[32] Emirates, "Annual Report 2020-2021," 2021. [Online] Available at: https://c.ekstatic.net/ecl/documents/annual-report/2020-2021.pdf Accessed Jul 23, 2023.
[33] Cathay Pacific, "Sustainable Development Report," 2021. Available at: https://sustainability.cathaypacific.com/wpcontent/uploads/2022/05/Cathay_Pacific_SDR_2021_EN_Final.pdf Accessed Jul 10, 2023.
[34] China Southern Airlines, "Corporate Social Responsibility Report," 2021. Available at: https://www.csair.com/en/about/investor/qitabaogao/2022/resource/144355e63b07bd454cec5111d7a23c0b.pdf Accessed Jul 20, 2023.
[35] WATS+, "World Air Transport Statistics," 2021. Available at: https://www.iata.org/contentassets/a686ff624550453e8bf0c9b3f7f0ab26/wats-2021-mediakit.pdf Accessed Jul 9, 2023.