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Corporate sustainability analysis: Evaluating the performance of IGA Istanbul Airport using LOPCOW and MAUT methods

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Abstract

This study comprehensively evaluates the corporate sustainability performance of İGA Istanbul Airport between 2019 and 2023 in terms of economic, environmental, and social dimensions. The study uses the Multi-Criteria Decision Making (MCDM) methods to measure the effectiveness of the airport's sustainability policies. The study determined the importance weights of the criteria using the LOPCOW (Logarithmic Percentage Change-driven Objective Weighting) method, while the airport's sustainability performance over the years was measured with the MAUT (Multi-Attribute Utility Theory) method. The findings indicate that İGA has made significant improvements in its sustainability performance over time. There was a decline in 2020 due to the impact of the COVID-19 pandemic, but a rapid recovery process began in 2021, and 2023 was the year in which the best performance was observed across all sustainability dimensions. In particular, the progress achieved in environmental sustainability indicators (carbon emissions, energy efficiency, waste management) demonstrates that the airport has taken significant steps toward achieving its long-term sustainability goals. The model developed in this study to evaluate the effectiveness of airport sustainability policies can be adapted to airports of different sizes and provides a framework to guide future applications and research.

Keywords: Corporate Sustainability, Airport Management, İGA Istanbul Airport, LOPCOW, MAUT **JEL Codes:** L93, Q01, Q56

Kurumsal sürdürülebilirlik analizi: İGA İstanbul Havalimanı'nın LOPCOW ve MAUT yöntemleriyle performans değerlendirmesi

Öz

Bu çalışma, İGA İstanbul Havalimanı'nın 2019-2023 yılları arasındaki kurumsal sürdürülebilirlik performansını ekonomik, çevresel ve sosyal boyutlarıyla kapsamlı bir şekilde değerlendirmektedir. Sürdürülebilirlik politikalarının etkinliğini ölçmek amacıyla çalışmada, Çok Kriterli Karar Verme (ÇKKV) yöntemleri kullanılmıştır. Çalışmada, kriterlerin önem ağırlıkları LOPCOW (Logarithmic Percentage Change-driven Objective Weighting) yöntemi kullanılarak belirlenirken, havalimanının yıllar içindeki sürdürülebilirlik performansı MAUT (Multi-Attribute Utility Theory) yöntemi ile ölçülmüştür. Bulgular, İGA'nın sürdürülebilirlik performansında yıllar içinde önemli gelişmeler kaydettiğini göstermektedir. 2020 yılında COVID-19 pandemisinin etkisiyle düşüş yaşanmış ancak 2021 itibarıyla hızlı bir toparlanma sürecine girilmiş, 2023 yılı ise tüm sürdürülebilirlik boyutlarında en iyi performansın gözlemlendiği yıl olmuştur. Özellikle çevresel sürdürülebilirlik göstergelerinde (karbon emisyonları, enerji verimliliği, atık yönetimi) sağlanan ilerlemeler, havalimanının uzun vadeli sürdürülebilirlik hedeflerine ulaşma yolunda önemli adımlar attığını göstermektedir. Havalimanlarının sürdürülebilirlik politikalarının etkinliğini ölçmek için geliştirilen bu model, farklı ölçeklerdeki havalimanlarına uyarlanabilir nitelikte olup, gelecekteki uygulamalara ve araştırmalara rehberlik edebilecek bir çerçeve sunmaktadır.

Anahtar Kelimeler: Kurumsal Sürdürülebilirlik, Havalimanı Yönetimi, İGA İstanbul Havalimanı, LOPCOW, MAUT **JEL Kodları:** L93, Q01, Q56

Introduction

The global aviation sector contributes approximately $4.1 trillion to the global economy, accounting for around 3.9% of the world's gross domestic product. It also provides employment for 86.5 million people worldwide. Research indicatea that the rapid development of the aviation sector will continue, with projections suggesting that by 2043, the aviation market will support 135.4 million jobs and contribute $8.5 trillion to the global economy (ATAG, 2025). Although aviation has become an indispensable part of the global economy, growing concerns about environmental sustainability have led to increased scrutiny of its impacts. In particular, large-scale infrastructure projects such as airports have drawn significant attention due to their environmental

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footprint (Graham, 2023). Therefore, the adoption and rigorous implementation of sustainability principles in such projects are crucial not only for the future of the aviation industry but also for the well-being of future generations.

Due to growing concerns about the environmental impacts of the aviation sector and increasing pressure from stakeholders, sustainability has become a key factor shaping airport operations in the 21st century (Raimundo et al., 2023). While airports offer various economic and social benefits to their stakeholders, they also generate significant environmental impacts, primarily noise and air pollution. The development of quieter aircraft and the implementation of noise reduction operating procedures have enabled most airports to mitigate the challenges associated with aircraft noise. However, in recent years, aircraft emissions have emerged as a growing environmental concern at airports (Graham, 2023).

Studies highlight that airports play a significant role in greenhouse gas emissions, with aviation contributing approximately 2.5% of global emissions (ATAG, 2025; Greer et al., 2020). Consequently, airports are increasingly recognized as key contributors to climate change, necessitating the adoption of sustainable initiatives to mitigate environmental impacts and promote long-term sustainability (Raimundo et al., 2023). In response, many airports have started to integrate sustainability into their strategic plans and environmental reports, acknowledging its importance beyond environmental concerns. Sustainability efforts are not only aimed at reducing ecological footprints but also at fostering economic and social resilience (Dimitriou & Karagkouni, 2022a).

To evaluate the effectiveness of sustainability strategies implemented by airports and identify areas for improvement, it is essential to measure corporate sustainability performance. Corporate sustainability is defined as an organization's ability to meet the needs of its current and potential stakeholders (including shareholders, employees, customers, pressure groups, and communities) without compromising its capacity to fulfill the needs of future stakeholders (Dyllick & Hockerts, 2002). It is typically assessed through a holistic approach that considers the interrelation of economic, environmental, and social dimensions (Aguilera et al., 2007; Bansal, 2005). In this context, measuring corporate sustainability performance is crucial for comprehensively evaluating the economic, environmental, and social impacts of airports on their stakeholders.

Due to the nature of airports, their complex operations, and collaboration with multiple stakeholders, sustainability assessment presents certain challenges. An examination of the existing literature on airport sustainability reveals that it generally focuses on reducing environmental impacts. In recent years, with the growing importance of economic and social dimensions, the number of studies on integrated sustainability assessments has increased (e.g., Di Vaio & Varriale, 2020; Jia et al., 2023; Lu et al., 2018). However, studies that evaluate airport sustainability performance using an objective and multi-dimensional approach—particularly those providing in-depth analyses through Multi-Criteria Decision Making (MCDM) methods—remain limited. This study aims to address this gap and contribute to the literature by comprehensively examining the corporate sustainability performance of İGA Istanbul Airport across its economic, environmental, and social dimensions.

To this end, this study focuses on the following key research questions:

• How is the economic, environmental, and social sustainability performance of İGA Istanbul Airport between 2019 and 2023?

• Is there a significant change in İGA's sustainability performance over this period?

• In which sustainability dimensions (economic, environmental, social) has the most progress been made, and in which areas is there potential for improvement?

To address these questions, the study will first conduct a detailed review of the airport sustainability literature and establish a conceptual framework. Then, using quantitative data obtained from İGA Istanbul Airport’s sustainability reports and the State Airports Authority (DHMI) data, corporate sustainability performance will be analyzed. Corporate sustainability performance measurement is a multi-criteria decision-making (MCDM) problem due to the diverse evaluation criteria it encompasses. In this context, MCDM methods are regarded as an appropriate approach for determining the weights of corporate sustainability performance indicators, assessing the sustainability performance of airports, and ranking them based on years and sustainability dimensions. Specifically, the LOPCOW (Logarithmic Percentage Change-driven Objective Weighting) method will be employed to determine the weights of the criteria, while the MAUT (Multi-Attribute Utility Theory) method will be used to assess the airport’s sustainability performance over the years. These methods will enhance the scientific validity and reliability of the study by ensuring objective criteria weighting and multi-dimensional performance evaluation.

In the subsequent sections, a comprehensive literature review on airport sustainability and MCDM methods will be presented. Next, the research methodology will be explained in detail, followed by the presentation and discussion of findings. Finally, the study's results will be summarized, theoretical and practical implications will be highlighted, and recommendations for future research will be provided. This study aims to contribute significantly to both academia and airport management practices by offering a systematic and objective evaluation of airport sustainability performance, using İGA Istanbul Airport as a case study.

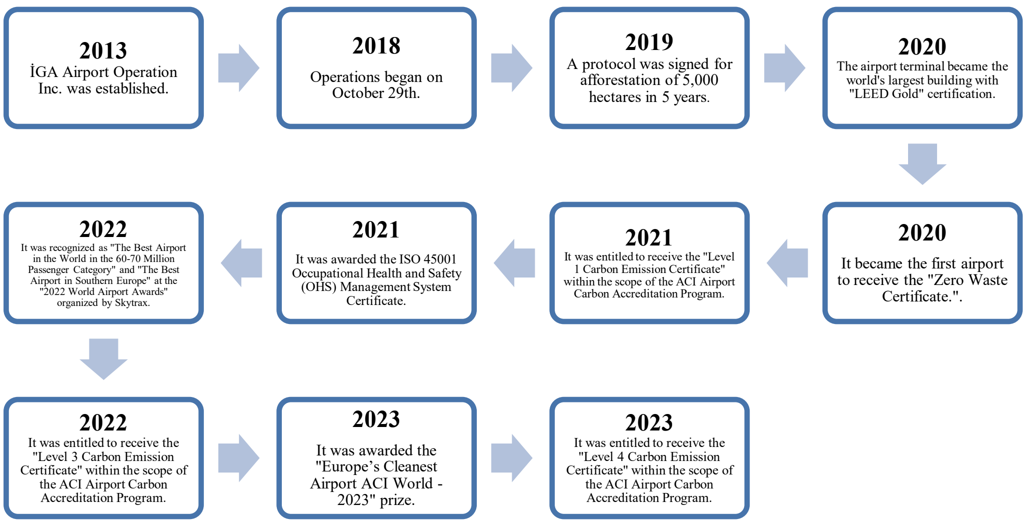
1. Sustainability Policies Of IGA Istanbul Airport

Istanbul Airport (IGA), as one of the most strategic transportation hubs in Türkiye and the region, stands out not only with its extensive capacity in passenger and cargo transportation, but also with its sustainability-focused practices. The airport, which began operations on October 29, 2018 and continues its operations at full capacity as of April 6, 2019, has an annual passenger capacity of 90 million. Hosting more than 250 million passengers in total as of the end of 2023, IGA provides direct flights to 315 different destinations in 130 countries. Considering the direct and indirect economic impacts of the airport, which has carried out more than 1.6 million flights from its opening until the end of 2023, it is estimated that its contribution to the Turkish economy will reach 24.2 billion dollars as of 2023. This contribution corresponds to approximately 2.2% of the country's total national income.

İGA adopts a sustainability approach in all its activities and conducts strategic studies in various areas, including energy efficiency, carbon emission reduction, waste management, water conservation, and social responsibility projects. Analyzing the sustainability reports of Istanbul Airport reveals that significant steps have been taken to minimize environmental impacts and fulfill social responsibilities. Within the scope of environmental sustainability, projects have been implemented in areas such as energy efficiency, waste management, water conservation, and biodiversity protection. In terms of social sustainability, various programs have been carried out to enhance employee well-being and contribute to local communities (İGA, 2019, 2020, 2023, 2024).

The foundations of IGA Istanbul Airport were laid in 2013, and it demonstrates its commitment to sustainability through the certificates and international accreditations it has received. The airport's pioneering position in environmental sustainability is evidenced by its “Zero Waste Certificate” and the world’s largest “LEED Gold” certified terminal building in 2020. In 2023, it further strengthened its progress in reducing carbon emissions by obtaining the Level 4 Carbon Emission Certificate under the ACI Airport Carbon Accreditation Program. Other certificates and achievement awards it has received are presented in Figure 1.

Figure 1. Sustainability and Corporate Achievements of İGA Istanbul Airport



Source: Compiled by the author from İGA sustainability reports (2023, 2024).

Within the framework of long-term sustainability strategies, İGA Istanbul Airport aims to achieve the “Net Zero Emission” target by 2050. In line with this goal, it is committed to reducing carbon emissions by 45% by 2030 and 73% by 2040. To support this effort, various strategies are being implemented for energy efficiency projects, renewable energy investments, stakeholder collaborations, and ecosystem transformation. As of 2023, thanks to waste management projects, 35% of waste has been recycled and reintegrated into the economy, with a target of increasing this rate to 50% by 2030. Additionally, 35% of the water used at the airport comes from recycled sources, contributing to a 5% reduction in water consumption per passenger in 2023.

Thanks to these measures, significant improvements have been achieved in economic, environmental, and social sustainability indicators. When environmental sustainability indicators are analyzed, it is evident that İGA Istanbul Airport has enhanced its operational efficiency. For instance, while energy consumption per passenger was 4.74 kWh in 2019, it rose to 7.77 kWh in 2020 due to the pandemic. However, thanks to the measures taken, it declined to 3.05 kWh in 2023, demonstrating a substantial improvement in energy efficiency. Similarly, emission intensity per passenger was 3.24 tons CO_2e in 2019 but decreased to 1.74 tons CO_2e in 2023.

There has also been a significant increase in the number of employees in terms of social sustainability. The workforce, which stood at 3,623 in 2019, expanded to 8,217 in 2023 as the airport's capacity grew. However, the percentage of female employees declined from 35% in 2019 to 27.9% in 2023. Likewise, although the proportion of female executives peaked at 16.1% in 2022, it dropped to 15% in 2023. On the other hand, there was a significant rise in training hours dedicated to employees' professional development. The total training duration, which was 116,594 hours in 2019, increased approximately 2.3 times, reaching 264,773 hours by 2023.

İGA Istanbul Airport also demonstrated improvements in economic sustainability performance. Although the number of passengers fell by 45% in 2020 due to the pandemic, dropping to 23 million, recovery began in 2021, reaching 76 million in 2023—surpassing pre-pandemic levels. Commercial air traffic followed a similar recovery trend, exceeding pre-pandemic figures in 2023. Meanwhile, cargo transportation was less affected by the pandemic and reached a capacity of 1.55 million tons in 2023, approximately 2.5 times the level recorded in 2019 (DHMİ, 2025).

In conclusion, İGA Istanbul Airport has made significant progress in sustainability and adopted a management approach focused on continuous improvement in economic, environmental and social dimensions. However, it is important to comprehensively analyze the sustainability indicators and determine the steps to be taken in the coming years. In this context, in the following section of the study, the corporate sustainability performance of İGA Istanbul Airport will be measured by multi-criteria decision making (MCDM) methods and evaluated according to years.

2. Literature Review

Corporate sustainability in the aviation sector, particularly in airports, has garnered increasing attention from both academics and practitioners. Stakeholders, shareholders, consumers, employees, and society are exerting growing pressure on businesses to assess their socioeconomic outcomes and manage them in a sustainable and resilient manner (Dimitriou & Karagkouni, 2022b). In this context, evaluating the sustainability performance of critical infrastructures such as airports is essential to ensuring their long-term viability.

The subject of airport sustainability has been addressed from different perspectives in the literature. Early studies focused on examining the environmental dimensions of airport operations. Airport environmental sustainability studies have focused on specific issues to address the practical problems of the airport, such as emission release(Parhamfar, 2024), noise pollution (Sreenath et al., 2021), air quality (Barrett et al., 2013), biodiversity (Kılkış & Kılkış, 2016), water management (Carvalho et al., 2013) and energy management (Bujok et al., 2023). Although these studies reveal methods that can be easily implemented in terms of application, they are insufficient to develop a holistic approach covering the entire system.

In recent years, due to the changes brought about by globalization and the problems it causes, researchers have emphasized the importance of the sustainability, and the necessity of addressing sustainability in economic, social and environmental terms. In today's market conditions, economic, social and environmental elements need to be addressed in a holistic manner in sectors or businesses (Epstein, 2018; Vural & Vural, 2024). In this context, it has become necessary to investigate the social and economic sustainability aspects of airports, as well as their environmental practices. This has led to the emergence of various approaches in the evaluation and comparison of airport sustainability performance.

For example, Lu et al. (2018) developed a sustainability-balanced scorecard model to measure the sustainability performance of airports. They identified sustainability performance measurement indicators through a review of the literature, expert opinions and interviews with managers at international airports. After determining the sustainability indicators, they created a hierarchical structure for the evaluation of the sustainable performance of international airports. In the performance evaluation, qualitative and quantitative data were analysed with multi-criteria decision-making methods. In the study, DEMATEL, DANP and VIKOR were used together to conduct a comprehensive evaluation. The proposed model was tested at three international airports in Taiwan as a case study.

Vaio and Varriale (2020) compare airports within the framework of the 17 Sustainable Development Goals (SDGs) published by the United Nations in 2015, addressing them in terms of organization, accounting, and reporting related to sustainable performance. For this purpose, a qualitative study was conducted by analyzing the financial statements and non-financial reports (sustainability and social reporting) of seven major strategic airport infrastructures in Italy. The study indicates that the analyzed Italian airport infrastructures do not fully meet the SDG targets, particularly SDG 11 and 17.

Jia et al. (2023) developed the Airport Sustainability Assessment Index (ASEI) to comprehensively evaluate the sustainability performance of airports. This model addresses sustainability across four dimensions: social, economic, operational and environmental. In the study, the determined sustainability indicators were first collected in the relevant sub-indices, and then the general composite index was formed. An analysis was carried out using Schiphol Airport's data from 2012-2021 to validate the model. The results revealed that the highest performance in the ten-year period was observed in 2019, while the lowest performances were observed in 2012, 2014 and 2016. In the analyses conducted using eight different combination schemes, a general consensus was reached on the high and low performance periods.

Karagiannis et al. (2019) conducted a comprehensive assessment of the sustainability policies of 193 international airports. In their study, they developed a methodology that suggesting that the materiality assessment for airport operators is an effective management tool that enhances business strategy and improves corporate performance. The article states that customer focus (health, safety and satisfaction), economic viability and business continuity and readiness are operational aspects of high importance.

Wang and Song (2020) analyzed airport performance from 2014 to 2021 to support airport sustainability planning and the formulation of sustainable airport development strategies. Their research focused on eight Chinese airports and four other Asian airports. In the study, airport performance was evaluated in detail, from the process level to the airport level, using the network DEA method with actual and predicted data obtained from the grey model.

Although various approaches have been applied in previous studies to evaluate the sustainability performance of airports, today's dynamic market environment necessitates a holistic approach that considers airports across economic, environmental, and social sustainability dimensions. In this context, multi-criteria decision-making methods were deemed appropriate for measuring sustainability performance, as each sustainability dimension consists of numerous indicators. Studies on corporate sustainability performance measurement have been conducted in various sectors using multi-criteria decision-making methods. These sectors include the electronics industry (Lee & Farzipoor Saen, 2012), the defense industry (Ayyildiz & Öztel, 2024), the energy sector (Öztel et al., 2018), the chemical sector (Alp et al., 2015), the white goods sector (Ersoy, 2018), the deposit banking sector (Sezal, 2024), the automotive sector (Yıldız Kaya & Öztel, 2018), the manufacturing sector (Aksoylu & Taşdemir, 2020), and the banking sector (Geçdoğan & Oral, 2020). Among the methods used in these studies, techniques such as CRITIC (Özkan & Ağ, 2021), EDAS (Yalçın & Karakaş, 2019), Entropy (Ersoy, 2018), MAUT (Alp et al., 2015), MAIRCA (Ayyildiz & Öztel, 2024), ARAS (Özkan & Ağ, 2021), and TOPSIS (Öztel et al., 2018) stand out.

3. Method

This study evaluates the corporate sustainability performance of İGA Istanbul Airport by analyzing sustainability reports published by İGA and statistical data from the State Airports Authority. Covering the period from 2019 to 2023, the research assesses the airport's economic, environmental, and social performance using 17 key sustainability indicators. These indicators play a crucial role in measuring airport performance, identifying infrastructure weaknesses, facilitating comparisons with other airports, and tracking progress toward sustainability goals (Greer et al., 2020). In this study, indicators from economic, environmental, and social dimensions were selected as key decision criteria. To determine the relative importance of these criteria, the LOPCOW method was applied. After establishing the criteria weights, the MAUT method was used to assess İGA Istanbul Airport's corporate sustainability performance over the years.

In this study, the LOPCOW method was preferred because it enables the determination of criteria weights with an objective mechanism that is completely data-driven and minimises the scale differences between criteria. This method produces results independent of the subjective influence of decision makers by revealing the relative importance of criteria through standard deviation-based percentage change calculations (Ecer & Pamucar, 2022). The MAUT method, on the other hand, aggregates the normalised utility values of sustainability indicators under a single integrated score; thus, it enables direct comparison between criteria of different dimensions and consistent performance ranking on a yearly basis (Alinezhad & Khalili, 2019; Ömürbek & Kişi, 2019).

Figure 2. Measuring Process of the Sustainability Performance of İGA Istanbul Airport

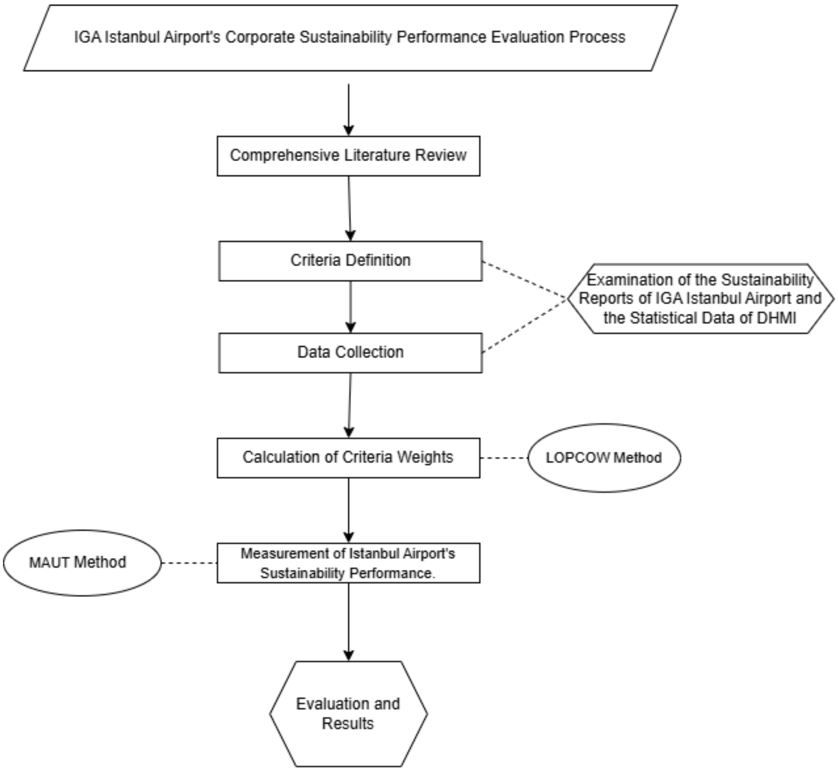


Figure 2 provides an overview of our research design. The process began with a comprehensive literature review to determine the current sustainability criteria in Istanbul Airport's sustainability reports. Then, the LOPCOW method was used to determine the weights of these criteria. The airport's sustainability performance over the years was assessed using the MAUT method. Finally, we interpreted the analysis results we obtained. In this way, we were able to compare the performance of IGA Istanbul Airport in different sustainability dimensions.

3.1. LOPCOW Method

The LOPCOW (Logarithmic Percentage Change-driven Objective Weighting) method is a multi-criteria decision-making approach that determines criterion weights objectively, without requiring input from decision-makers. Developed by Ecer & Pamucar (2022), the method derives optimal weights by integrating data of varying scales. It aims to minimize inconsistencies in the importance levels of different criteria, ensuring a balanced consideration of various factors.

This relatively new method has been applied in diverse fields, including cargo company selection (Özbek, 2025), city evaluation (Keleş, 2023), banking sector performance analysis (Gülcemal & İzci, 2023), automotive company profitability analysis (Çetin & Karataş, 2024), artificial intelligence readiness assessment (Altıntaş, 2024), innovation performance analysis (Öztaş & Öztaş, 2024), logistics performance analysis (Özekenci, 2024), passenger satisfaction analysis (Bakır & İnce, 2024), electric vehicle selection (Güler, 2024), economic performance evaluation of countries (Kahreman, 2024), comparison of information and communication technologies (Keleş, 2024), and supplier selection (Ecer & Pamucar, 2022) .

The following steps are used to calculate criterion weights using the LOPCOW method (Ecer & Pamucar, 2022).

Step 1: Constructing the Decision Matrix

An initial decision matrix (IDM) is constructed for a decision problem with m alternatives and n criteria.

$$IDM = \begin{bmatrix} y_{11} & y_{12} & \cdots & y_{1n} \\ y_{21} & y_{22} & \cdots & y_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ y_{m1} & y_{m2} & \cdots & y_{mn} \end{bmatrix} \qquad (1)$$

Step 2: Constructing the Normalized Decision Matrix

In this step, the decision matrix is normalized. Equation (2) is used for benefit-based criteria, while Equation (3) is applied for cost-based criteria.

$$r_{ij} = \frac{x_{ij} - x_{min}}{x_{max} - x_{min}} \qquad if\ j \in B \qquad (2)$$

$$r_{ij} = \frac{x_{max} - x_{ij}}{x_{max} - x_{min}} \qquad if\ j \in C \qquad (3)$$

Step 3: Calculating the Percentage Values of the Criteria

In this step, the percentage value of the criteria; the mean square value is calculated as the percentage of the standard deviations of each criterion. With the help of Equation (4), the gap differences between the criteria are eliminated.

$$PV_{ij} = \left| \ln \left(\frac{\sqrt{\frac{\sum_{i=1}^{m} \hat{x}_{ij}^2}{m}}}{\sigma} \right) .100 \right| \quad (4)$$

Here, σ and m represent the standard deviation and the number of alternatives, respectively.

Step 4: Calculating the Weights of the Criteria

Finally, the objective importance weights (w_j) for each criterion are calculated using Equation (5).

$$W_j = \frac{PV_{ij}}{\sum_{i=1}^{n} PV_{ij}} \quad (5)$$

Equation (5) ensures that the sum of the criteria weights equals 1 ($\sum_{i=1}^{n} w_j = 1$).

3.2. MAUT Method

The MAUT (Multiple Attribute Utility Theory) method analyzes alternatives based on utility values derived from criteria to solve decision problems involving both quantitative and qualitative factors (Alinezhad & Khalili, 2019). The primary objective of MAUT is to maximize the U utility function, which is defined over the alternatives considered in decision problems (Ömürbek & Kişi, 2019).

Recent MAUT applications cover air transport performance analysis (Ömürbek & Akçakaya, 2018), capacity assessment (Başdeğirmen & Çal, 2021), export performance analysis (Maruf & Özdemir, 2021), supplier selection (Eş & Kocadağ, 2020), warehouse location selection (Ergün et al., 2020), drone selection (Demir & Boz, 2024) and benchmarking innovation capabilities (Orhan & Yalçın, 2022).

The MAUT method consists of five stages, which are as follows (Alinezhad & Khalili, 2019; Altan et al., 2021; Karakış, 2021; Vargün et al., 2020):

Step 1: Determination of criteria and alternatives

In this step, the criteria (an), sub-criteria (xm) and alternatives of the decision problem are determined.

Step 2: Assignment of weight values

In the evaluation of the alternatives in the decision problem, the weight values (w_j) are assigned. The sum of the weight values must be equal to 1.

$$\sum_{i=1}^{a} w_j = 1 \quad (6)$$

Step 3: Determining the Weighted Decision Matrix

In this step, the decision matrix is created by assigning the value measurements of the criteria. Assignment is created with numerical expressions for quantitative criteria. Assignment is made with pairwise comparisons for qualitative criteria.

Step 4: Calculation of Normalized Benefit Values

After the decision matrix is created, the best and worst values for each criterion are determined for normalization. In this process, the best value is 1 and the worst value is 0. Then, the following Equation (7) formula is used to calculate the other values.

$$u_i(x_i) = \frac{x - x_i^-}{x_i^+ - x_i^-} \quad (7)$$

The terms used in the equation are explained as follows.

X_i^+: Best value for the alternative

X_i^-: Worst value for the alternative

X: Current benefit value in the calculated line

Step 5: Determining the total benefit value

Following the normalization process, benefit values are determined. The benefit function is shown with the help of the equation

(8) given below:

$$U_{(X)} = \sum_{1}^{m} u_i \, (x_i)^{*} w_j \quad (8)$$

(8) $U_{(X)}$: Benefit values of alternatives,

$U_i(X_i)$: Normalized benefit values for each criterion and alternative

W_j: Weight values

4. Application and Findings

In this study, the sustainability reports of İGA Istanbul Airport from 2019 to 2023 were examined and economic, environmental and social sustainability criteria were identified. In determining these criteria, attention was paid to the inclusion of the criteria in the sustainability reports and their measurability. In this context, the number of passengers, aircraft traffic, freight traffic, cargo traffic, water consumption, energy consumption, emission intensity per passenger, prevented greenhouse gas emissions, total waste amount, waste recycling rate, oil saving, raw material saving, energy saving, number of employees, female employee ratio, female manager ratio and training hours provided to employees were determined as economic, environmental and social sustainability indicators. The sustainability indicators, along with their explanations and purposes, are presented in Table 1. Each of the sustainability indicators has a maximum (benefit) or minimum (cost) effect on performance.

Table 1. Criteria Used to Evaluate Sustainability Performance

	Code	Indicators	Objective
Economic Sustainability	C1	Passenger number	Max (Benefit)
	C2	Commercial aircraft traffic	Max (Benefit)
	C3	Freight traffic (Baggage + Cargo + Mail)	Max (Benefit)
	C4	Cargo traffic	Max (Benefit)
Environmental Sustainability	C5	Water consumption (m^3/passenger)	Min (Cost)
	C6	Energy consumption (kWh/passenger)	Min (Cost)
	C7	Emission intensity per passenger (tons CO_2e)	Min (Cost)
	C8	Prevented greenhouse gas emissions (tons)	Max (Benefit)
	C9	Total waste amount (tons)	Min (Cost)
	C10	Waste recycling rate (%)	Max (Benefit)
	C11	Oil savings (barrels)	Max (Benefit)
	C12	Raw material savings	Max (Benefit)
	C13	Energy savings (million kWh)	Max (Benefit)
Social Sustainability	C14	Number of employees	Max (Benefit)
	C15	Female employee ratio (%)	Max (Benefit)
	C16	Female manager ratio (%)	Max (Benefit)
	C17	Training hours provided to employees	Max (Benefit)

The study examined the corporate sustainability performance of Istanbul Airport between 2019-2023. For this purpose, data were compiled from the sustainability reports published annually by IGA Istanbul Airport (İGA, 2019, 2020, 2023, 2024) and the State Airports Authority statistical reports (DHMİ, 2025). The data used in the analysis is presented in Table 2.

Table 2. Data Used in Analysis

	Code	Indicators	2019	2020	2021	2022	2023
Economic Indicators	C1	Passenger number	52.009.220	23.410.380	37.181.907	64.518.073	76.011.907
	C2	Commercial aircraft traffic	326.407	178.918	273.115	415.600	489.674
	C3	Freight traffic	1.492.908	965.640	1.529.778	2.700.482	2.899.211
	C4	Cargo traffic	590.962	494.602	783.304	1.504.372	1.552.336
Environmental Indicators	C5	Water consumption (m^3/passenger)	0,0256	0,0354	0,0273	0,0206	0,0196
	C6	Energy consumption (kWh/passenger)	4,74	7,77	5,67	3,63	3,05
	C7	Passenger emission intensity (tons CO_2e)	3,24	5,4	3,97	2,18	1,74
	C8	Prevented greenhouse gas emissions (tons)	1.056	297	640	977	1.079
	C9	Total waste amount (tons)	26.727	16.326	25.372	43.507	53.135
	C10	Waste recycling rate (%)	31	16	31	34	35
	C11	Oil savings (barrels)	37.841	13.149	62.718	103.375	103.436
	C12	Raw material savings	1977	297	484	1.625	2.731
	C13	Energy savings (million kWh)	35	10	32	51	52
Social Indicators	C14	Number of employees	3.623	6.517	7.031	8.032	8.217
	C15	Female employee ratio (%)	35	27	26,6	27,3	27,9
	C16	Female manager ratio (%)	13,9	15,2	15,7	16,1	15,0
	C17	Training hours provided to employees	116.594	49.296	157.830	228.214	264.773

4.1. Findings Of the LOPCOW Method

In this section of the study, the importance weights of the criteria were calculated using the LOPCOW method. A decision matrix was created for each corporate sustainability dimension in the analysis. The economic sustainability decision matrix includes four criteria, the environmental sustainability decision matrix includes nine criteria, and the social sustainability decision matrix includes four criteria. In the decision matrix, the relevant activity year of the airport is listed in the rows, while the sustainability performance criteria are presented in the columns. Since there is no negative value in the financial data, no conversion was made. Since each criterion may have a maximum or minimum effect on performance, the optimum values of the criteria must be entered correctly in the analysis. All economic and social sustainability criteria have maximum effect. While C5, C6, C7, and C9 of the environmental sustainability criteria have a minimum effect, the others have maximum effect. In order to obtain correct results in the analysis, these effects must be decided correctly.

Table 3. Decision matrix

	Max	Max	Max	Max
	C1	**C2**	**C3**	**C4**
2019	52.009.220	326.407	1.492.908	590.962
2020	23.410.380	178.918	965.640	494.602
2021	37.181.907	273.115	1.529.778	783.304
2022	64.518.073	415.600	2.700.482	1.504.372
2023	76.011.907	489.674	2.899.211	1.552.336

	Min	Min	Min	Max	Min	Max	Max	Max	Max
	C5	**C6**	**C7**	**C8**	**C9**	**C10**	**C11**	**C12**	**C13**
2019	0,0256	4,74	3,24	1.056	26.727	31	37.841	1977	35
2020	0,0354	7,77	5,4	297	16.326	16	13.149	297	10
2021	0,0273	5,67	3,97	640	25.372	31	62.718	484	32
2022	0,0206	3,63	2,18	977	43.507	34	103.375	1.625	51
2023	0,0196	3,05	1,74	1.079	53.135	35	103.436	2.731	52

Table 3. Continue.

	Max	Max	Max	Max
	C14	**C15**	**C16**	**C17**
2019	3.623	35	13,9	116.594
2020	6.517	27	15,2	49.296
2021	7.031	26,6	15,7	157.830
2022	8.032	27,3	16,1	228.214
2023	8.217	27,9	15,0	264.773

After the creation of the decision matrices, each element was normalized. The normalization process was performed using Equation (2) and Equation (3) according to whether they were benefit-oriented or cost-oriented. The normalized values of the initial decision matrix are given in Table 4.

Table 4: Normalized decision matrix

	C1	C2	C3	C4
2019	0,5437	0,4746	0,2727	0,0911
2020	0,0000	0,0000	0,0000	0,0000
2021	0,2618	0,3031	0,2918	0,2729
2022	0,7815	0,7616	0,8972	0,9547
2023	1,0000	1,0000	1,0000	1,0000

	C5	C6	C7	C8	C9	C10	C11	C12	C13
2019	0,6203	0,6419	0,5902	0,9706	0,7174	0,7895	0,2735	0,6902	0,5976
2020	0,0000	0,0000	0,0000	0,0000	1,0000	0,0000	0,0000	0,0000	0,0000
2021	0,5127	0,4449	0,3907	0,4386	0,7542	0,7895	0,5490	0,0768	0,5238
2022	0,9367	0,8771	0,8798	0,8696	0,2616	0,9474	0,9993	0,5456	0,9762
2023	1,0000	1,0000	1,0000	1,0000	0,0000	1,0000	1,0000	1,0000	1,0000

	C14	C15	C16	C17
2019	0,0000	1,0000	0,0000	0,3123
2020	0,6300	0,0476	0,5909	0,0000
2021	0,7418	0,0000	0,8182	0,5037
2022	0,9597	0,0833	1,0000	0,8303
2023	1,0000	0,1548	0,5000	1,0000

The percentage values (PV) of each criterion, obtained using Equation (4), were calculated from the normalized values. Then, weights (W_j) of each criterion were determined using Equation (5). The calculated PV values and criterion weights are presented in Table 5.

Table 5. Percentage Values (PV) and Criterion Weights (W_j)

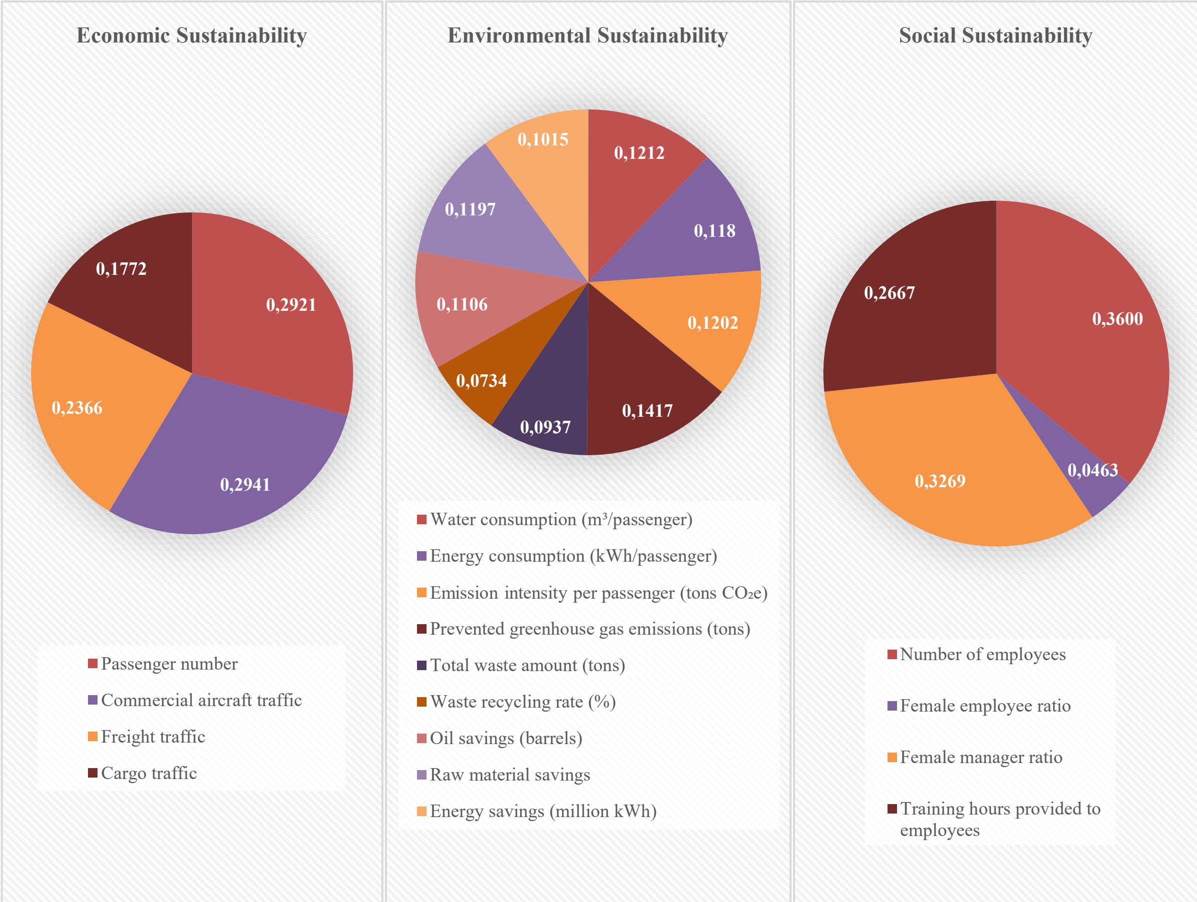
	C1	C2	C3	C4
2019	0,29560	0,22526	0,07436	0,00830
2020	0,00000	0,00000	0,00000	0,00000
2021	0,06854	0,09188	0,08512	0,07450
2022	0,61073	0,58008	0,80501	0,91136
2023	1,00000	1,00000	1,00000	1,00000
σ	0,3989	0,3897	0,4337	0,4793
PV	45,4669	45,7787	36,8206	27,5835
W_j	0,2921	0,2941	0,2366	0,1772

	C5	C6	C7	C8	C9	C10	C11	C12	C13
2019	0,38471	0,41210	0,34829	0,94204	0,51471	0,62327	0,07479	0,47641	0,35715
2020	0,00000	0,00000	0,00000	0,00000	1,00000	0,00000	0,00000	0,00000	0,00000
2021	0,26282	0,19795	0,15265	0,19239	0,56889	0,62327	0,30142	0,00590	0,27438
2022	0,87742	0,76934	0,77402	0,75614	0,06842	0,89751	0,99865	0,29768	0,95295
2023	1,00000	1,00000	1,00000	1,00000	0,00000	1,00000	1,00000	1,00000	1,00000
σ	0,4001	0,3944	0,3995	0,4303	0,4056	0,4053	0,4422	0,4214	0,4079
PV	57,4338	55,8979	52,3889	56,9369	48,0991	67,1170	44,3641	34,7754	56,6854
W_j	0,1212	0,1180	0,1106	0,1202	0,1015	0,1417	0,0937	0,0734	0,1197

	C14	C15	C16	C17
2019	0,00000	1,00000	0,00000	0,09754
2020	0,39684	0,00227	0,34917	0,00000
2021	0,55032	0,00000	0,66942	0,25371
2022	0,92108	0,00694	1,00000	0,68946
2023	1,00000	0,02395	0,25000	1,00000
σ	0,4026	0,4191	0,3795	0,4000
PV	63,1871	8,1259	57,3804	46,8161
W_j	0,3600	0,0463	0,3269	0,2667

All the above processes have been implemented separately for economic, environmental and social sustainability criteria. The weights of the criteria to be used in measuring the corporate sustainability performance of the airport are summarized in the graphs below.

Figure 3. Criteria Weights



4.2. Findings Of the MAUT Method

The MAUT method was employed in this study to compare Istanbul Airport's corporate sustainability performance over the years. In the initial phase of the MAUT method, the best values in the matrix are assigned a value of one, while the worst values are assigned a value of zero. Accordingly, the best and worst values of the economic, environmental, and social sustainability criteria must be determined. The best and worst values in the decision matrix are presented in Table 6. 359

Table 6. Best and Worst Values of Economic, Environmental, and Social Sustainability Criteria

	C1	C2	C3	C4
Best Value	76.011.907	489.674	2.899.211	1.552.336
Worst Value	23.410.380	178.918	965.640	494.602

	C5	C6	C7	C8	C9	C10	C11	C12	C13
Best Value	0,0196	3,05	1,74	1.079	52	35	103.436	2.731	52
Worst Value	0,0354	7,77	5,40	297	10	16	13.149	297	10

	C14	C15	C16	C17
Best Value	8.217	35,0	16,1	264.773
Worst Value	3.623	26,6	13,9	49.296

After identifying the best and worst values, a normalized utility value matrix is created. Normalization is applied to the criteria using Equation (7). The normalized utility values are presented in Table 7.

Table 7. Normalized Utility Values

	C1	C2	C3	C4
2019	0,5437	0,4746	0,2727	0,0911
2020	0,0000	0,0000	0,0000	0,0000
2021	0,2618	0,3031	0,2918	0,2729
2022	0,7815	0,7616	0,8972	0,9547
2023	1,0000	1,0000	1,0000	1,0000

	C5	C6	C7	C8	C9	C10	C11	C12	C13
2019	0,6203	0,6419	0,5902	0,9706	0,7174	0,7895	0,2735	0,6902	0,5976
2020	0,0000	0,0000	0,0000	0,0000	1,0000	0,0000	0,0000	0,0000	0,0000
2021	0,5127	0,4449	0,3907	0,4386	0,7542	0,7895	0,5490	0,0768	0,5238
2022	0,9367	0,8771	0,8798	0,8696	0,2616	0,9474	0,9993	0,5456	0,9762
2023	1,0000	1,0000	1,0000	1,0000	0,0000	1,0000	1,0000	1,0000	1,0000

	C14	C15	C16	C17
2019	0,0000	1,0000	0,0000	0,3123
2020	0,6300	0,0476	0,5909	0,0000
2021	0,7418	0,0000	0,8182	0,5037
2022	0,9597	0,0833	1,0000	0,8303
2023	1,0000	0,1548	0,5000	1,0000

After forming the normalized utility value matrix, the weighted utility matrix is obtained by multiplying the normalized values by the criterion weights determined using the LOPCOW method. This process is carried out using Equation (8). The weighted utility matrix is presented in Table 8.

Table 8. Weighted benefit matrix

	C1	C2	C3	C4	MAUT Ranking
2019	0,059	0,043	0,011	0,001	3
2020	0,000	0,000	0,000	0,000	5
2021	0,012	0,017	0,012	0,008	4
2022	0,144	0,135	0,171	0,154	2
2023	0,294	0,296	0,238	0,178	1

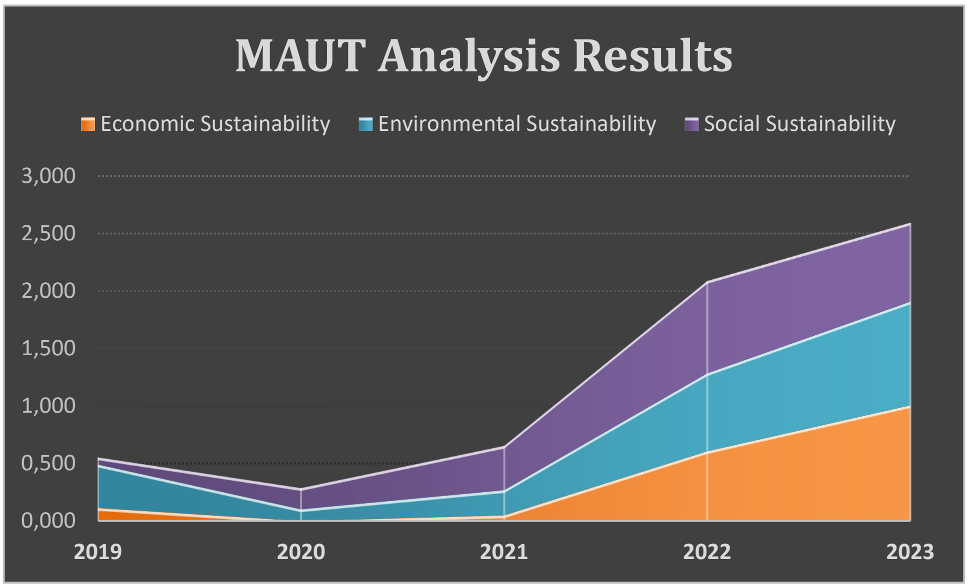
	C5	C6	C7	C8	C9	C10	C11	C12	C13	MAUT Ranking
2019	0,033	0,035	0,027	0,110	0,040	0,072	0,004	0,026	0,030	3
2020	0,000	0,000	0,000	0,000	0,102	0,000	0,000	0,000	0,000	5
2021	0,021	0,015	0,011	0,015	0,045	0,072	0,019	0,000	0,022	4
2022	0,100	0,080	0,076	0,079	0,004	0,120	0,094	0,015	0,112	2
2023	0,122	0,119	0,111	0,121	0,000	0,142	0,094	0,074	0,120	1

Table 8. Continue.

	C14	C15	C16	C17	MAUT Ranking
2019	0,000	0,047	0,000	0,016	5
2020	0,103	0,000	0,080	0,000	4
2021	0,154	0,000	0,182	0,045	3
2022	0,318	0,000	0,329	0,155	1
2023	0,362	0,001	0,054	0,268	2

As a general assessment of the analysis, it is seen that İGA Istanbul Airport has improved its sustainability performance from 2019 to 2023. The findings show that the airport has entered a rapid recovery process since 2021 after the decline in 2020 due to the Covid 19 pandemic. Significant progress is seen in many areas, especially in 2022 and 2023. In addition to the increase in the number of passengers, traffic volume and cargo amount, improvements were recorded in water and energy consumption per unit passenger and emission intensity. In addition, positive developments were observed in environmental indicators such as prevented greenhouse gas emissions, waste recycling rate, energy, oil and raw material savings. The increase in the number of employees, the rate of female employees and managers, and the increase in the training hours given to employees reflect the airport's efforts in the field of social sustainability. The findings show that the airport performed best in economic and environmental sustainability indicators in 2023 and in social sustainability indicators in 2022. Considering all criteria, 2023 is seen as the most successful year. The corporate sustainability performance results of İGA Istanbul Airport by year are presented in Figure 4.

Figure 4. İGA Istanbul Airport's Corporate Sustainability Performances



4.3. Sensitivity Analysis

In this section, a sensitivity analysis was conducted to evaluate the robustness of the LOPCOW–MAUT-based model against changes in the importance weights of the criteria. In this analysis, the weight of the most important criterion in the initial scenario was reduced by 5%, and the reduced portion was redistributed among the other criteria. By applying this weight modification separately for each criterion, a total of 20 different scenarios were generated. The aim is to examine how small changes in criterion weights affect the corporate sustainability performance scores of İGA Istanbul Airport calculated using the MAUT method, as well as the performance ranking by year. For each scenario, the weights were calculated using Equation (9).

$$W_{n\beta} = (1 - W_{n\alpha}) * \frac{W_\beta}{(1-W_n)} \quad (9)$$

In Equation (9):

W_β denotes the original weight of a non-perturbed criterion,

W_n represents the original weight of the most important criterion,

$W_{n\alpha}$ represents the reduced weight value of the most important criterion under the scenario and

$W_{n\beta}$ refers to the updated weight values of all other criteria under the scenario (Kirkwood, 1997; Asker & Kılınç, 2025).

This approach ensures that when the weight of the criterion with the highest importance is reduced, the proportional balance among the remaining criteria is maintained and the total weight remains equal to 1. Thus, the criterion weight structure is restructured consistently under each scenario.

Figure 5. Distribution of Criteria Weights Across Scenarios (Economic, Environmental, and Social Dimensions)

The results of the sensitivity analysis indicate that small variations in criterion weights do not significantly affect the overall performance ranking, as the ranking remained largely stable across most scenarios. Based on the initial weight configuration and the MAUT scores for the years 2019–2023, 2023 ranked as the year with the highest sustainability performance, while 2020 had the lowest performance. In the majority of the twenty scenarios, this ranking structure remained unchanged; 2023 consistently maintained its top position, and 2020 continued to occupy the lowest rank.

Figure 6. Sensitivity Analysis Results: Yearly Sustainability Scores by Scenario

Sensitivity analysis findings show that the sustainability performance evaluation model of İGA Istanbul Airport is reliable and consistent against small parameter fluctuations. The presence of only limited and reasonable variations in the MAUT ranking indicates that the decision outputs remain largely robust when the criteria weights are determined by objective methods. In particular, the fact that the first place in 2023 does not change generally supports that our conclusion regarding the effectiveness of the airport's sustainability policies (the result of achieving the best performance in 2023) is also valid according to the sensitivity analysis.

Discussion And Conclusion

This study aimed to provide a comprehensive evaluation of İGA Istanbul Airport's corporate sustainability performance from 2019 to 2023 across economic, environmental, and social dimensions. To ensure an objective analysis, multi-criteria decision-making (MCDM) methods were employed. The LOPCOW method was used to determine the weights of sustainability indicators, while the MAUT method measured the airport's overall sustainability performance. This approach allowed for a quantitative assessment of the effectiveness of İGA Istanbul Airport's sustainability policies.

The criteria weights calculated by the LOPCOW method highlight the dominant role of economic and environmental factors in assessing sustainability performance. Among economic indicators such as passenger numbers and commercial flight traffic stand out as the criteria with the highest weight, while prevented greenhouse gas emissions, water consumption and waste recycling rate were determined as the most important factors among environmental criteria. These findings reveal that the sustainability success of airports is directly related to their economic size and capacity to control environmental impacts. In terms of social sustainability, the number of employees and the rate of female managers have a significant effect while the effect of the rate of female employees and the hours of training provided seems to be more limited.

The analysis conducted with the MAUT method clearly revealed the changes in the sustainability performance of İGA Istanbul Airport. In 2020, there were significant decreases in economic indicators (e.g. passenger numbers and commercial flight traffic) and environmental indicators (energy consumption, carbon emissions, waste management) due to the pandemic. However, it is observed that the recovery process started in 2021, and significant improvements were recorded in these indicators in 2022 and 2023. In particular, the rapid recovery in the economic field and the significant decrease in carbon emissions in environmental performance reveal how effective the airport's sustainability strategies are. In the social dimension, the increase in the number of employees and the increase in training hours reflect the concrete benefits of investments made in human resources. According to the ranking obtained from the MAUT analysis, 2023 was the most successful period both economically and environmentally, while

2020 stood out as the lowest-performing year when the pandemic effects were intense.

Despite the significant decline in economic sustainability indicators (such as passenger numbers, commercial aircraft traffic, and freight and cargo traffic) in 2020, a rapid recovery has been observed since 2021. The increase in cargo traffic, particularly after the pandemic, appears to have made a positive contribution not only to economic sustainability but also to Turkey's logistics sector. The "Zero Waste Certificate" awarded to İGA in 2020 and the fact that it hosts the world's largest LEED Gold-certified terminal building suggest that its commitment to environmental and resource management has yielded positive impacts beyond environmental sustainability, extending to economic benefits as well. Such certifications enhance the airport's corporate reputation among international investors and business partners, fostering new business opportunities and collaborations. Furthermore, these achievements are reinforced by İGA being recognized as the "World's Best Transfer Airport" and "Southern Europe's Best Airport" by Skytrax in 2022.

İGA Istanbul Airport showed the best performance in environmental sustainability performance indicators (water consumption, energy consumption, emission intensity, waste management and energy, oil, and raw material amounts saved) in 2023. In particular, the reduction in emission intensity per passenger unit from 3.24 tons CO_2e in 2019 to 1.74 tons CO_2e in 2023 shows that İGA's carbon management strategies are successful. This situation is also in line with the airport's achievement of Level 1 certification in 2021, Level 3 in 2022 and Level 4 in 2023 under the ACI Airport Carbon Accreditation Program. In addition, the "Zero Waste Certificate" (2020) and the increase in the waste recycling rate from 31% to 35% demonstrate that waste management practices are gradually strengthening. Despite the increase in the total amount of waste (increased to 53,135 tons in 2023), the increase in the recycling rate shows that sustainable waste policies are paying off in the field. These improvements can be considered as important developments in reaching the airport's long-term "Net Zero Emission" target set for 2050.

The social sustainability indicators examined in this study—including the number of employees, the ratio of female employees and female managers, and training hours—demonstrate that İGA has made significant strides in employment and employee development. The increase in the number of employees from 3,623 in 2019 to 8,217 in 2023 confirms that the airport has expanded in parallel with its growing operational capacity. However, the decline in the ratio of female employees from 35% in 2019 to 27.9% in 2023, as well as the decrease in the proportion of female managers from its peak of 16.1% in 2022 to 15% in 2023, highlights the need for further improvements in gender equality. While being recognized as the "World's Most Family-Friendly Airport" by Skytrax in 2022 demonstrates İGA's global recognition in terms of social sustainability and customer experience, new strategies should be developed to promote female employment and enhance diversity in managerial positions. On the other hand, the fact that employee training hours increased approximately 2.3 times between 2019 and 2023 indicates that İGA has made significant progress in employee development and competency management.

In conclusion, İGA Istanbul Airport has demonstrated significant progress in its sustainability journey, particularly in its recovery from the pandemic-induced setbacks. While economic and environmental performance have shown strong improvements, particularly in 2023, further efforts are needed to enhance social sustainability, specifically in promoting gender equality and diversity within its workforce. The MCDM approach provides a valuable framework for ongoing monitoring and improvement of İGA's sustainability performance.

This study provides multifaceted contributions to the airport sustainability literature. At the conceptual level, an integrated framework has been developed that addresses the economic, environmental, and social dimensions of IGA Istanbul Airport together. This shows that it differs from previous studies that are predominantly environmentally focused. In terms of methodology, it combines the objective weighting competence of LOPCOW with the benefit-based ranking power of MAUT and presents a model that is applied for the first time in airport sustainability assessments, minimizes subjective biases, and allows long-term comparison. Empirically, it reveals sustainability trends using five-year longitudinal data covering the pre-pandemic period, its duration, and the post-pandemic period, and supports conceptual discussions with concrete findings. In terms of application, the developed indicator set and analytical process contribute to stakeholders in creating sustainability roadmaps by providing a decision-support template that can be adapted to other airports regardless of scale. This holistic approach opens new discussion and application channels for both researchers and practitioners in the field of aviation management.

The data used in the study is limited to the sustainability reports published by İGA İstanbul Airport and the statistics of the State Airports Authority. In addition, although an objective assessment was made using the LOPCOW and MAUT methods in the study, analyses conducted with different Multi-Criteria Decision Making (MCDM) methods may produce different results. In addition, the study focused only on İGA İstanbul Airport and no comparative analysis was made with other international airports of similar size. In future studies, more comprehensive assessments can be made with comparisons with different airports and qualitative analyses that examine the social sustainability dimension in depth.

Author Contributions

The author has not declared any other contributors.

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The author(s) did not report ethical committee approval as the research content does not require.

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