International Journal of Social Inquiry, *18*(1), 2025, pp. 51-70
journal homepage: https://dergipark.org.tr/en/pub/ijsi

International Journal of Social Inquiry
International Peer-Reviewed Open Access Electronic Journal
E-ISSN: 1307-9999
Volume 18 Issue 1 April 2025

RESEARCH ARTICLE / Araştırma Makalesi
https://doi.org/10.37093/ijsi.1524169

The Role of Accounting in Managing Climate Change and a Practice in the Aviation Industry

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Abstract

Companies are in constant interaction with the environment because they necessarily produce wastes that have no economic value while performing their production activities. The elimination of such wastes is a separate cost element and can cause some environmental damages in the geography in question. Reducing damages, eliminating wastes, providing accurate information about environmental performance, making improvements, spreading the use of environmentally sensitive technologies, monitoring and accounting for environmental costs incurred require acting within the scope of green transformation. In this context, environmental accounting (green, carbon, sustainability, climate change) applications come into play. The aim of the study is to examine the role of accounting in emissions and costings originating from the civil aviation sector within the scope of minimizing or preventing the negative elements that create climate change. Another reason for conducting the study in this area is that it has the fastest and highest growth potential in terms of per capita carbon emissions among all transportation types. The fact that the flight numbers of a very small area in Turkish civil air traffic are sampled in the study is considered important in terms of showing how devastating the consequences of uncontrolled conditions can be when compared to the general. The aim of the study is to provide a better understanding of the negative effects of climate change, to show the extent of the damages, to draw attention to the accounting of costs and to bring a different perspective to the literature in the field of aviation by creating awareness about climate change.

Anahtar Kelimeler: Climate Change, Climate Change Accounting, Emissions, Aviation Industry

JEL Kodları: M40, M41, M42, M49, M10, L93

Cite this article: Yaylalı, İ. & Karaman, F. (2025). The role of accounting in managing climate change and a practice in the aviation ındustry. *International Journal of Social Inquiry*, *18*(1), 51-70. https://doi.org/10.37093/ijsi.1524169

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Article Information

Received 29 July 2024; Revised 30 January 2025; Accepted 05 February 2025; Available online 30 April 2025

İklim Değişikliğinin Yönetilmesinde Muhasebenin Rolü ve Havacılık Sektöründe Bir Uygulama

Öz

Şirketler üretim faaliyetlerini gerçekleştirirken ekonomik değeri olmayan atıklar ürettikleri için çevre ile sürekli etkileşim halindedirler. Bu tür atıkların bertarafı ayrı bir maliyet unsuru olup söz konusu coğrafyada bazı çevresel zararlara yol açabilmektedir. Zararların azaltılması, atıkların bertaraf edilmesi, çevresel performans hakkında doğru bilgi sağlanması, iyileştirmeler yapılması, çevreye duyarlı teknolojilerin kullanımının yaygınlaştırılması, oluşan çevresel maliyetlerin izlenmesi ve muhasebeleştirilmesi yeşil dönüşüm kapsamında hareket etmeyi gerektirmektedir. Bu bağlamda çevre muhasebesi (yeşil, karbon, sürdürülebilirlik, iklim değişikliği) uygulamaları devreye girmektedir. Çalışmanın amacı, iklim değişikliğini yaratan olumsuz unsurların en aza indirilmesi veya önlenmesi kapsamında sivil havacılık sektöründen kaynaklanan emisyon ve maliyetlendirmelerde muhasebenin rolünü incelemektir. Çalışmanın bu alanda yapılmasının bir diğer nedeni ise tüm ulaşım türleri arasında kişi başına karbon emisyonu açısından en hızlı ve en yüksek büyüme potansiyeline sahip olmasıdır. Çalışmada Türk sivil hava trafiğinde çok küçük bir bölgenin uçuş sayılarının örneklemlenmiş olması, kontrolsüz koşulların sonuçlarının genele kıyasla ne kadar yıkıcı olabileceğini göstermesi açısından önemli görülmektedir. Çalışmanın amacı, iklim değişikliğinin olumsuz etkilerinin daha iyi anlaşılmasını sağlamak, zararların boyutlarını ortaya koymak, maliyet muhasebesine dikkat çekmek ve iklim değişikliği konusunda farkındalık yaratarak havacılık alanındaki literatüre farklı bir bakış açısı getirmektir.

Anahtar Kelimeler: İklim Değişikliği, İklim Değişikliği Muhasebesi, Emisyonlar, Havacılık Endüstrisi

JEL Kodları: M40, M41, M42, M49, M10, L93

1. Introduction

Since the industrial revolution, industry and trade, which have developed rapidly with globalization, have gradually increased the need for energy and natural resources. It has led to the emergence of some ecological problems in meeting these needs. The most important of these ecological problems is climate change due to global warming. It is the accumulation of greenhouse gas emissions in the atmosphere that causes climate change (Gürbüz et al., 2019). Climate change, also known as global warming, is the sudden changes in the average temperatures measured in the sea, air and land caused by the release of produced greenhouse gases into the atmosphere and extreme weather events. The main reasons causing climate change are; destruction of forests, release of waste gases into the atmosphere and deterioration of the environment. While all these negative situations lead to sudden changes in climate change, it is thought to negatively affect human health in every aspect (Tong & Ebi, 2019). In other words, climate change is caused by reasons such as rapid population growth, deforestation, excessive use of natural lands and resources, and greenhouse gas emissions resulting from the excessive use of fossil-based energy types in different sectors within the scope of economic activities (Birpınar, 2022).

The problem of climate change is one of the important issues on the world's agenda. Deforestation, unconscious consumption of fossil fuels, industry, urbanization, etc., human-induced factors increase environmental problems and this situation paves the way for negative situations in climate change. In order to raise awareness against climate change, some climate actions such as blocking traffic, attacks on famous works, and disrupting social events are organized (Canbolat & Tarlakazan, 2024).

The 2018 "Climate Change Panel Global Warming Special Report" predicts that the world has warmed by 1ºC compared to the pre-industrial period due to human activities, and that if these activities continue, global warming will exceed the 1.5ºC limit between 2030 and 2052. Therefore, attention is drawn to the fact that water scarcity, extreme heat and ecosystem deterioration are occurring with the emergence of climate change, and it is stated that rapid transformations should be made in factors such as industry, urbanization, soil, transportation, etc. in order for the temperature to remain at 1.5ºC (Intergovernmental Panel on Climate Change, 2020). In Türkiye, according to the comprehensive 2021 report prepared by the "Global Climate Change Research Commission of the Grand National Assembly of Türkiye"; "Due to the measures not taken every passing day, it is emphasized that hail disasters, tornadoes, droughts, floods and forest fires are occurring more frequently and that our country's ecological balance is being further damaged. In addition, as the ecological balance is disrupted, hurricanes, floods and fires cost the lives of more living things" (TBMM İklim Raporu, 2021).

Although the increasing climate change and the threats posed by the lifestyles of living beings in the world to ecosystems have been proven by scientists, there is still inadequacy in taking the necessary precautions against the environment. The necessity of fictional narratives about how the damages arising within the scope of climate change distort human life and nature continues to be a frequently emphasized and discussed topic especially in Western academic circles today (Yavaş, 2024). Humans and unlimited needs create significant pressure on the environment, especially climate change. In order to minimize these pressures, many countries have been allocating resources to serious research in recent years and taking initiatives to develop new approaches. The relevant search and development also finds a place in academic studies (Alaeddinoğlu, 2023).

There are assessments that use scientific indicators that climate change poses more threats to ecosystems. At the beginning of these assessments, it is argued that most of these threats are caused by human activities. Industry, energy, land, transportation, building and city-based human activities are among the factors thought to cause the climate change problem (Kaymaz & Tut, 2020). Scientific studies emphasize that the negative effects of climate change will be severe, rapid and more widespread, and it is stated that no region or sector will be exempt from these effects (Demiralp, 2022).

The main purpose of the study is to address the role of accounting in preventing or minimizing the effects of waste, emissions, etc. factors that cause climate change. In other words, the function of accounting in costing environmental damage caused by activities is attempted to be revealed. In the study, the measurements of the factors that cause climate change are analyzed by using the data of a company operating in the aviation sector. First of all, the importance of climate change and climate change accounting is addressed in the study. Then, in order to reveal the importance of the subject more clearly, the data of a company operating in the aviation sector is evaluated. A literature review has been conducted for the study and it is seen that there are practical and theoretical studies in national and international literature on climate change. In the study, the aviation sector, which plays an important role in climate change, is taken as an example and the role of accounting in environmental costs is attempted to be explained. The study differs from other studies in this respect. The research aims to contribute to the literature with this sample.

2. Climate Change, Definition and Scope of Climate Change Accounting

Climate change is a global problem that significantly affects various functions. In recent years, there has been serious damage in the rate of meteorological and climatic disasters due to climate change. These disasters cause both loss of life and property.

Climate change occurs with the increase in heat-holding gases and unexpected extreme events in the climate. As a result of increasing deforestation and the greenhouse gases released harming nature, it harms all living things and causes climate change (Aydem Enerji, 2022). Climate change is the accumulation of greenhouse gas emissions resulting from human activities in the atmosphere, abnormal global temperatures and rapid changes in climate values (Karaman, 2021).

Climate change and environmental damage are important issues in the world's focus today (Murshed et al., 2021; Wang et al., 2023). Climate change has maintained its place in the scientific world and has been the subject of numerous studies. Climate change and environmental concerns have begun to emerge in developing countries as well as in developed countries (Al-Swidi et al., 2023; Aslam et al., 2021). Environmental conditions caused by climate change create some risks for businesses. It creates negative risks such as fluctuations in energy supply, instability, disruption of continuity management, damage to profitability, increasing supply and industry chain risk, interruption of production, delay of logistics and reduction of R&D investments (Huynh et al., 2020; Engle et al., 2020; Javadi & Masum, 2021).

The environment today faces many challenges such as air and water pollution, deforestation, and biodiversity loss (Liu et al., 2022). Factors such as careless industrial practices, industrialization, increasing consumer expectations, insensitivity to the environment, inefficient use of resources, and inequalities between different segments of society have had detrimental effects on the environment (Baah et al., 2021). As a result of global warming, freshwater resources are drying up, glaciers are melting, sea levels are rising, and species are disappearing. Türkiye is a country that will be affected by the consequences of climate change, and this has now increased concerns in both individuals and sectors (Varol & Ayaz, 2012). Projected changes in the climate threaten agricultural productivity and the communities whose economic livelihoods depend on it (Ortiz-Bobea et al., 2021). In order to overcome this challenge, recent studies emphasize the importance of quantifying adaptation to changing climate conditions (Carleton et al., 2022; Hultgren et al., 2022).

After the industrial revolution, rapid population growth and unconscious consumption have significantly affected the environment and caused major problems (Wang et al., 2014). The world is faced with global warming, pollution, mismanagement of natural resources and environmental destruction, which paves the way for sustainability problems. Therefore, businesses need to support sustainable development goals within the scope of minimizing or preventing these environmental problems. It is important for businesses to create the necessary strategies to meet the needs of future generations while protecting the resources they may need (Ratmono et al., 2024).

Companies produce goods or services using raw materials and other materials in production. The waste generated in production harms the environment as much as possible. Therefore, companies inevitably distort nature while meeting consumer expectations. Along

with all this, rapid changes in the climate are now changing consumers' habits and preferring environmentally friendly products. Consumers' preference for environmentally friendly products reduces sales and operating profits in terms of ensuring economic sustainability of companies (Latifah & Soewarno, 2023). However, consumers prefer to do business with companies that have a strong structure. In other words, environmental records or investors may be more likely to invest in companies that prioritize sustainability, and this gives their stakeholders a competitive advantage (Li et al., 2020).

Due to the increasing concerns of consumers and shareholders about environmental issues, companies are encouraged to make improvements in climate change in terms of reducing the negative effects of climate change, conducting activities according to their ecological impact, and reporting accurately (Gunarathne et al., 2021). In particular, companies are aligning their climate disclosures with sustainability reporting within the framework of standards such as the Global Reporting Initiative (GRI) or the Sustainability Accounting Standards Board (SASB) (Dye et al., 2021).

Global warming, eco-efficiency and other industrial activities that have a direct impact on the environment are emerging, and the accounting field has a significant impact on environmental problems and nature conservation as corporate activities. The accounting field plays an important role in the disclosure of environmental costs in financial reports (Panggabean & Deviarti, 2022). It is possible for companies to evaluate the effectiveness of climate investments in reducing greenhouse gases with accurate accounting data. The accounting field encourages a more targeted approach to high-impact projects and resource allocation optimization, and especially to reduce emissions (Krefeld-Schwalb & Gabel, 2023). There are many difficulties in reporting climate-related financial data accurately in current accounting practices and are insufficient in decisions regarding climate change (Zhou, 2022). In other words, the fact that the data is not distributed to the right sources makes it difficult to collect and analyze effectively. This situation prevents comprehensive reporting. In addition, the lack of a standard poses a significant challenge within the scope of climate accounting frameworks (Kim et al., 2023). Therefore, in today's society, the importance of an environmentally and morally responsible economic understanding is increasing and practices should be prioritized (Khan et al., 2021). Accounting discipline is important for sustainable development (Pizzi et al., 2022). Companies and investors rely on financial information for decision-making. Incorrect or incomplete climate finance accounting can lead to misallocation of resources. This situation directs investors to either high-risk or less sustainable projects (Naveed et al., 2020). In addition, climate-related risks pose significant threats to financial markets, and within the scope of accountability and transparency, these risks can lead to unexpected market fluctuations and affect economic stability (Zhang, 2022). Sustainable and economic development-related issues have become important issues globally within the scope of ensuring environmental sustainability in parallel with social progress, and it is an important step for companies to fulfill their environmental responsibilities during their production (La Soa et al., 2024).

Companies include current and potential future impacts of climate change in integrated and sustainability reports, which are non-financial reports. In recent years, regulations have been made in independent auditing and international financial reporting standards regarding

climate change, which require that the financial impacts of non-financial elements be included in the financial statements together with their footnotes and annexes. In particular, the International Accounting Standards Board has emphasized that the impacts of climate change should be reported in accordance with International Financial Reporting Standards in terms of resources, assets and income/expenses of businesses (Arzova & Şahin, 2022).

It is important for companies to adapt to the conditions brought by climate change and ensure their continuity. It is important for companies to report the wastes that arise from their activities and have no economic value in the relevant accounting records in a reliable and accurate manner. At this stage, those working in the field of finance and accounting need to integrate the elements affecting climate change into accounting. The traditional accounting system is insufficient in recording climate change. For this reason, the accounting field has developed the concepts of "environmental accounting" and "green accounting" in the phase of monitoring, recording and taking necessary precautions regarding environmental problems. However in recent years, climate change which has been experienced as a result of the emergence of factors that harm nature, has come to the fore and where the concepts of "environmental accounting" and "green accounting" fall short in analyzing events, the more comprehensive "climate change accounting" comes into play (Karcıoğlu & Öztürk, 2023). In light of all this information; In order for business managers to obtain precise information about the costs, benefits and results of economic activities, they need accurate and reliable information on the subject. In this context, since climate accounting is a part of accounting information, the financial and managerial aspects of the system need to be taken into account (Novićević Čečević et al., 2023).

While the unlimited needs of human beings increase day by day, it is imperative for businesses to meet these demands in order to ensure sustainability. Accordingly, the increasing diversity in activities also creates environmental problems. Financial statements prepared by businesses are inadequate, especially when it comes to calculating the environmental costs arising from activities. Therefore, since the extent of damage to the environment cannot be measured exactly, it is impossible to reduce the rate of possible negative effects.

Today, climate change is one of the most important environmental problems. While both individual and social awareness is increasing, it is seen that businesses are also obliged to participate in this. Businesses take action in calculating the costs of environmental damage according to their sector and structure. Most importantly, credit institutions, investors, etc. Other stakeholders are not satisfied with just financial statements and want to have information about non-financial data as well. For this reason, businesses are now turning to creating the infrastructures necessary for sustainable development.

Factors such as climate change, damage to natural areas, energy and food crisis have become very important for sustainable development (Bozoğlu & Ciğerim, 2022). Therefore, as developing technology and competition create change in all areas, they also accelerate innovation and change in the field of business. In this respect, the nature of the information requested by stakeholders has changed and not only financial information but also non-financial information is requested (Ömürbek & Acun, 2021). In this context, businesses prepare

sustainability reports indicating that they carry out their environmental, social and economic activities (Özbingöl & Acar Uğurlu, 2024).

With the adoption of the concept of sustainability, the reflection of sustainability-related reporting on economic life has also been accelerated. International Financial Reporting Standards (IFRS) economic ability has come to the fore regarding issues related to financial sustainability issues and declared that the International Sustainability Standards Board (ISSB) was established in 2021. In other words, financial and sustainability reporting are now gathered under the same roof. In March 2022, texts about the two standards proposed by the ISSB were published and presented for their comments. Then, two standards proposed by ISSB came into force on June 26, 2023. Among the standards in question, IFRS S1; It is "designed to enable companies to provide investors with the information they need to make decisions" and IFRS S2 declares the "specific climate-related disclosures" section. "Turkish Sustainability Reporting Standards" and "Scope of Application of Turkish Sustainability Standards" were published in the Official Gazette dated 29/12/2023 and numbered 32414 (1.M), and "Sustainability Reporting Standards in Turkey" (TSRS) was published as of 01.01.2024. has been made mandatory. Businesses that exceed at least two of the specified criteria in two consecutive reporting periods are required to prepare sustainability reports. The criteria in question are as follows (KGK, 2024):

- Number of employees of 250 people and above
- Total assets of 500 Million Turkish Liras and above
- Annual net sales revenue of 1 Billion Turkish lira and above

In this context, non-financial data are reported in addition to financial statements, thus stimulating the interactions of businesses with the environment. Factors such as reduced consumption, more cautious use of resources, reduced energy loss and recycling of waste as a result of the preparation of sustainability reporting ultimately increase the efficiency of businesses. Therefore, expanding accounting infrastructures in calculating the costs of environmental damages, in other words, creating detailed account items, provides social benefits to the environment and society, while also supporting the state to earn more income.

3. Climate Change and the Aviation Industry

The transportation sector and its sub-branch, the civil aviation field, are among the business lines that are as effective as individual habits in the emergence of climate change. The civil aviation sector is increasing its share in the sector day by day thanks to its features such as speed, comfort and safety compared to other transportation alternatives. Based on the data published by the International Civil Aviation Organization, abbreviated as ICAO, it was reported that 4.5 billion people used commercial air transportation in civil aviation in 2019 (ICAO, 2019). This figure was also stated as approximately 100 million people for the 60s in the previous reports of the relevant institution. Due to the Covid 19 pandemic experienced after 2019, there was a decrease in transportation figures due to factors outside the sector. In order to make the effects of the pandemic the main factor in the interpretation of the reports prepared in the following years and to make more realistic comparisons, ICAO's 2019 reports were used in the

study. The main reason why the civil aviation sector is taken into consideration within the scope of climate change in 2022 is that it has a great impact on carbon values due to carbon emissions formed at high altitudes and that it has achieved rapid growth rates as a sector. Although the civil aviation sector causes less carbon emissions compared to land transportation, it is understood that it is the sector with both the fastest and the highest growth potential when the per capita carbon emission values are examined under the influence of technological developments and operational efficiency in recent years (European Commission, 2021).

According to ICAO (2019) reports, it is stated that the carbon emission effects caused by civil aviation will be three times higher in 2050 compared to 2015. However, it is stated that 2.4% of the global carbon dioxide emission values in 2018 were caused by the commercial civil aviation sector, and when this sector is considered as a country, it will be in 6th place among Germany and Japan, which are among the top ten countries in global carbon dioxide emission levels. For example, it is stated that the carbon emission caused by a plane making a round-trip flight between London and Montreal or Lisbon and New York is equal to the carbon emission release that an average European Union (EU) citizen will produce by heating their home for only one year. Furthermore, when the carbon dioxide level per person resulting from just one flight is compared, it is revealed that it can be equal to a person driving a gasoline-powered car for one year (European Commission, 2021). According to Roy (2021), 90% of the emissions caused by aircraft occur during flight above 3,000 feet (approximately 915 m). The other 10% share occurs during the landing and take-off of aircraft. In the light of all information, it is stated that all carbon emissions have effects on air quality according to Gürçam, Konuralp and Ekici (2021).

As can be understood from the studies, commercial aviation not only has benefits for human life but also has harms due to the carbon emission it produces. In this regard, considering Türkiye's growth rate and geography, the IPCC (2021) reports state that the Mediterranean region is among the top countries in terms of carbon and emissions and that it should be controlled because it is the region that will be most affected by climate change. Roy (2021) explains that there has been no significant development in the implementation of the expected rules and sanctions in the ongoing process with the Kyoto Protocol and the Paris Agreement. Contrary to expectations, international aviation and maritime transport were exempted from the rules and sanctions to be implemented and the responsibilities for the emissions to be caused by these sectors were transferred to the International Civil Aviation Organization (ICAO) and the World Maritime Organization, together with the "limitation or reduction" targets. In addition, commercial aviation emissions were not included in the content of the Paris Agreement signed in 2015. According to Gössling and Humpe (2020), as a result, calculating or controlling emissions from both passenger and cargo aircraft in commercial air transportation has become much more difficult.

4. Literature

In recent years, some studies have been carried out in order to reduce the emissions caused by the civil aviation sector, more intensively. The EU Emission Trading System is the first study conducted within the scope of combating climate change. In fact, this study, which is more of

a market-based study, cannot be considered very successful in terms of reducing carbon and emission values. Aviation companies participating in the ETS system can avoid liability in terms of reducing carbon dioxide emissions because they think they have received a kind of prior permission to pollute the environment. While ETS, which is considered the most advanced step in combating climate change by the European Union, offers a more economical and more efficient plan by constantly tightening emissions in practice, it has had the opposite effect in the implementation phase, negatively affecting the reduction of pollution levels and the transition to a sustainable fair economy. Because the system has become a kind of rewarding tool rather than limiting the biggest polluters, namely large airline companies. In aviation practice, ETS, which only covers domestic flights within the European Union, has had the opposite effect on large companies since it does not cover international flights, which have the main impact and are seen as a source of emissions. Therefore, the ETS system, which covers only carbon dioxide emissions, also hides the effects of all other harmful gases originating from aircraft (Corporate Europe Observatory, 2011).

Another important step taken to reduce emissions from world civil aviation is CORSIA, which is put into effect by ICAO. In short, CORSIA is a global balancing plan for possible growth in carbon dioxide emissions of all airlines and operators above 2020 levels (Air Transport Action Group, 2020). In fact, it is an application that allows the sector to grow while balancing global carbon dioxide emissions. Again, it is a market-based mechanism like ETS, and it is not a reduction plan, and it does not set any targets for reducing emissions. In other words, it does not present an obligation or liability for airlines to reduce their own carbon emissions. Although there has been an application to balance the emissions caused by international flights since 2020, the effects of harmful gases caused by flights on climate change continue. Therefore, the effects of greenhouse gases have not been strongly reduced in terms of combating climate change with this application (Atmosfair, 2021). As the main mission, the EU Emissions Trading System and the Carbon Offset and Reduction Scheme for International Aviation (CORSIA) are working on the use of sustainable aviation fuels and technological developments to reduce emissions from aviation activities worldwide (European Commission, 2021). As in other sectors, no conclusion could be reached in the aviation sector on this issue at the 26th Meeting of the Conference of the Parties held in Glasgow, Scotland between 31 October and 12 November 2021. In the relevant meeting, since no agreement was reached on the target of limiting carbon emissions, which is increasing the impact of the aviation sector, which is rapidly growing in order to combat climate change, in the relevant meeting, binding decisions could not be taken in general terms (Steiner, 2021).

In terms of managing climate change, the most dominant point in sustainable aviation emissions and carbon emissions is undoubtedly fuel use. Therefore, unless an effective step is taken in the fuel use section in the aviation sector, it will be inevitable for emissions from this sector to increase in parallel with use. As a result of research, it has been revealed that sustainable alternative fuels are 10 percent more efficient than kerosene-based fuels used in most aircraft, and palm oil fuels are 14 percent more efficient than kerosene-based fuels. The important point here is that palm oil production has some destructive effects. Because palm oil causes greenhouse gases throughout its life cycle, and the greenhouse gas rate produced is three times higher than the greenhouse gas produced by conventional oils. Even when

compared to this result, the fact that fossil fuels cause 10 percent higher emissions than conventional fuels allows them to be accepted as sustainable alternative fuels (Stay Grounded, 2019). Considering that the 2019 data could provide more accurate results due to the pandemic experienced all over the world, when the relevant dated reports are examined, it is seen that more than 200,000 tons of "Sustainable Aviation Fuel" was produced in total as of 2019. However, even this figure constitutes a very small part of the annual fuel amount of 300 million tons of jet fuel used especially for commercial aviation activities. For this reason, even if all planned aviation fuel projects are carried out in the following years, a maximum of 4 million tons of sustainable aviation fuel can be produced. Therefore, when compared to the expectations of the total sector in 2030, it can be predicted that sustainable aviation fuels will always be more expensive than fossil fuels, since 1 percent of jet fuel demand will be met, even if there is a cost decrease.

There are two effective emission problems in the air transportation sector caused by aircraft engines. The first effect is the formation of high levels of hydrocarbons as a result of the excessive fuel consumption in order to obtain high combustion effect with low power during ground maneuvers of aircraft before take-off, and the necessity to reduce this hydrocarbon level in return. The second is the nitrogen oxides formed during take-off, climb and flight of the aircraft. In order to eliminate these problems, the International Civil Aviation Organization (ICAO) has determined standards for the landing/take-off cycle and upper-level cruise, called LTO. In this way, it is aimed to control air pollution at airports and deformation of the ozone layer in the atmosphere. In addition to the movements of aircraft that cause harmful gas emissions to the environment at airports, there are also ground service equipment, land service vehicles, mobile heat and power generation units. According to published reports, 5 to 6 percent of the fuel consumed in our world is used by passenger aircraft. According to Ünal, Türkoğlu and Doğan (2014), the amount of fuel consumed per person in old-type aircraft is calculated as 12 lt., while it is stated that this figure is around 3.5 lt. in new-generation aircraft. When the rates of emissions from aircraft engines are examined, it is understood that an average of 70% is CO2. It is explained that the remaining part is 29% H2O and the last 1% consists of other harmful emissions. However, it should not be forgotten that these rates vary as a result of factors such as the engine types of the aircraft used, the fuel they use, the distances flown and the altitude. There are many studies conducted on this subject. Tınmaz et al. (2002), who investigated the flights made to Tekirdağ/Çorlu airport by companies that organize flights to our country from the former Soviet countries, mostly Russia, examined the emissions at the LTO level in their studies. In another study, in 2003, Kaygusuz (2003) explained that NOX and CO emission rates examined at LTO level in previous years constituted 0.25% to 0.3% of total emission levels when considered in Türkiye as a whole. In the study prepared by Kesgin (2006) on ICAO emission information, emission values of major airports in Türkiye including Atatürk Airport were calculated depending on both minimum and maximum fuel consumptions by utilizing LTO emission data and fuel viscosity. As a result of the research, total emission rates of the relevant airports were found to be in the range of 7,614.34-8,338.79 tons/year. In contrast to the exemplification of the first studies in this way, in recent years, examples have been given by Ekici et al. (2013), by using flight information of the five busiest airports in Türkiye and ICAO emission parameters, they determined CO, HC and NOX emissions

as 1483, HC as 215 and NOX as 1417 tons/year in their research results. Again, in another research conducted in Atlanta Airport, which is shown as the busiest airport in the world in the same years, Rismann et al. (2013) examined LTO emission values using the Advanced Modeling System for Transport, Emissions, Reactions and Deposition of Atmospheric Matter model, shortly called AMSTERDAM. Another study conducted using the Lagrangian particle method as another way in the distribution of aircraft exhaust emissions was recorded as belonging to Pecorari et al. (2016). In the relevant study, the temporal and spatial exhaust distribution of aircraft was analyzed to investigate the details of LTO cycles. In another study at Kayseri Airport, Yılmaz (2017) stated that reducing the taxi time of aircraft proceeding on the runway by 2 minutes could provide a 4% reduction in total LTO emissions.

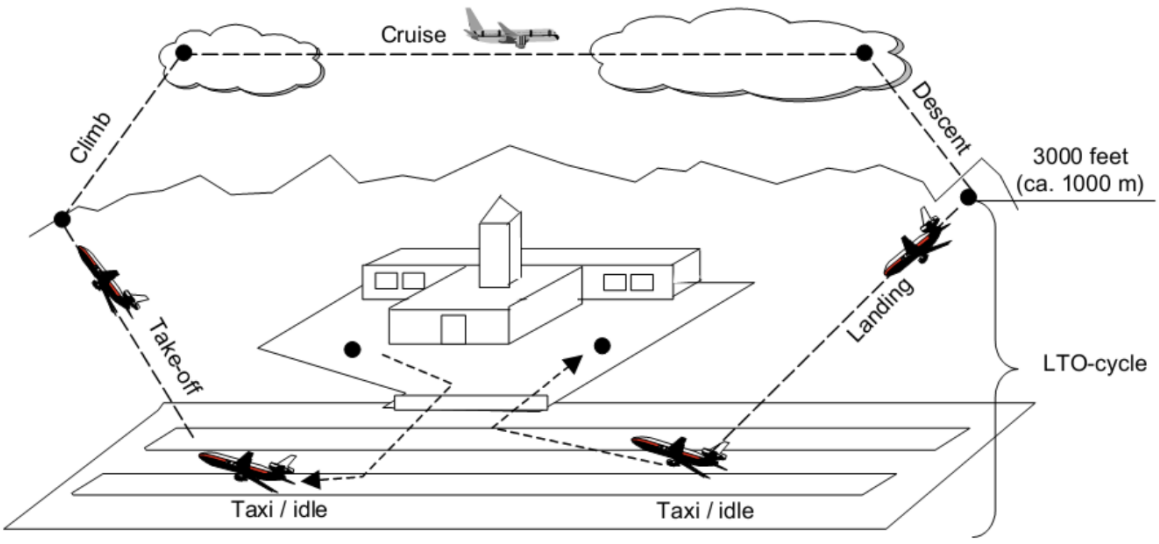
Aircrafts spend a significant portion of their planned fuel during take-off. Therefore, the intensity of the emission level mostly occurs during the take-off times of the aircraft. In the calculations of the type mentioned, the primary things to know are the manufacturers, models, LTO numbers, CO2 levels and numbers of the aircraft, as they affect fuel consumption.

In aviation literature, LTO consists of two parts. The first part is called the landing/takeoff of the aircraft, waiting in the parking position with all engines running, loading or unloading passengers, and all landing and climbing activities up to 3000 feet/approximately 915 m (Özdemir, 2013). The second part is called level flight or cruise and covers the movements from the climb above 1000 meters to the landing stage (Babaoğlu & Özgünoğlu, 2017).

In line with this information, verbal expressions regarding the LTO cycle are visualized in Figure 1.

Figure 1

LTO Cycle (IPCC, 1997)



5. Research

In all emission calculations stated in the literature, the Tier approach methodology recommended by the IPCC is mostly used. The main reason for this can be shown as the

significant amount of CO2 in greenhouse gases generated due to transportation services. Therefore, it can be thought that the increase in the CO2 rate at the same rate as fuel consumption, i.e. the increase in fuel consumption, increases CO2 emissions. In this study, again by using the Tier methodologies recommended by the IPCC, the flight data of Ankara Esenboğa Airport, which is among the busiest airports in Türkiye, was examined over the recent years. It was understood from the State Airports Authority (DHMI) reports that the Boeing 737-800, Airbus A320 and A 321 type aircraft, which are the most used aircraft types in the world, are used more at the relevant airport. Therefore, the annual flight numbers were first found over the first three aircraft models used the most in the study. Then, the Tier methodology was applied to the flight numbers and emission values were calculated. Thus, in the light of the obtained data, it was planned to see the difference according to aircraft types.

5.1 Purpose of the Research

The aim of the study is to show the effects of the aviation sector in managing climate change with the methods and reports used. In addition to the benefits of the civil aviation sector such as speed, quality and comfort, it is important to reveal its effects on climate change and to show the variability between the types of aircraft and technologies used. In addition, it is thought that the study will contribute to the literature by showing how devastating the results will be if the flight numbers, a very small portion of which are used, are not controlled when considered inductively.

5.2 Method of the Research

The Tier 1 and Tier 2 methods used in emission calculations are methods prepared and recommended by the IPCC (IPCC, 1991). First, the Tier 1 method is obtained by multiplying the LTO and the amount of fuel consumed during the cruise by the emission factor. Therefore, fuel consumption is taken as the basis in this method and is calculated by using the emission factor depending on the amount and type of fuel consumed. In the other method, Tier 2, the emission amounts resulting from the use of vehicles are also added to the calculation. For this reason, it is stated that the results obtained will be more sensitive as more data is needed in the Tier 2 method. This method is used to calculate the emissions of aircraft using jet fuel and for this reason, the LTO number and the type information of the aircraft are needed during the calculation. Thus, the LTO emission is obtained by multiplying the LTO emission factor and the LTO number (Babaoğlu & Özgünoğlu, 2017). For this reason, firstly, preparing a table for the relevant aircraft types, aircraft LTOs and dates will be useful for making more detailed calculations. The real figures for the relevant data can be obtained from the civil aviation activity reports published by each country. In Türkiye, real figures can be obtained from the annual reports published by both the State Airports Authority (DHMI) and the General Directorate of Civil Aviation (SHGM). It is important to prefer the detailed ones according to the aircraft types in the relevant reports.

5.3 Findings and Comments

According to the 2024 Activity Report of the State Airports Authority (DHMİ), in the distribution of aircraft traffic in Türkiye by aircraft type in 2023, Boeing 737-800 type aircraft will be in the first place with 26%, Airbus A 321 with 11% and Airbus A 320 with 7% (DHMİ, 2024). This rate consisted of 29% Boeing 737-800, 10% Airbus A 321 and 8% Airbus A 320 type aircraft in 2022 (DHMİ, 2023). In 2021, it consisted of 31% Boeing 737-800, 8% Airbus A 321 and 8% Airbus A 320 type aircraft (DHMİ, 2022). In 2020, which was affected by the pandemic, the relevant figures were 35% Boeing 737-800, 7% Airbus 321 and 7% Airbus A 320 (DHMİ, 2021). Since only the first three aircraft types with the most flights will be used in the calculations, other aircraft types will not be used in order to prevent confusion. In the calculations, the table created as a result of the ratios of the flight numbers to the relevant percentages in the Activity Report published by the State Airports Authority in 2024 was used.

Table 1

Commercial Flight Traffic of Ankara Esenboğa Airport in Türkiye (DHMİ, 2024)

PERIOD / FLIGHT NUMBERS	ANKARA ESENBOĞA (ESB) AIRPORT		
	DOMESTIC	INTERNATIONAL	TOTAL
2020	32.883	6.891	39.774
2021	43.510	11.854	55.364
2022	45.734	14.716	60.450
2023	59.699	20.457	80.156
TOTAL	181.826	53.918	235.744

Source: (DHMI, 2024).

Table 2

Flight Traffic by Aircraft Types at Ankara Esenboğa Airport in Türkiye (DHMİ, 2024)

A.C. TYPES	%	2020 FLIGHT NUMBERS	%	2021 FLIGHT NUMBERS	%	2022 FLIGHT NUMBERS	%	2023 FLIGHT NUMBERS	TOTAL FLIGHT NUMBERS
BOEING 737-800	% 35	13.921	% 31	17.163	% 29	17.531	% 26	20.841	69.456
AIRBUS A 321	% 7	2.784	% 8	4.429	% 10	6.045	% 11	8.817	22.075
AIRBUS A 320	% 7	2.784	% 8	4.429	% 8	4.836	% 7	5.611	17.660
TOTAL		19.489		26.021		28.412		35.269	109.191

Source: (DHMI, 2024).

The flight traffic data of Ankara Esenboğa (ESB) airport prepared according to the State Airports Authority reports are shown in Table 1 and Table 2. Based on the relevant tables, it is understood that the number of flights has increased in recent years. The decrease in the effects of the pandemic process experienced in 2019 and later can also be shown as a factor in the increase in the numbers. In addition, it is understood that the usage rates of Airbus type aircraft have not changed much, especially in the face of the small decrease in the usage of Boeing 737-800 type aircraft. The figures should not mean that the number of flights of Boeing aircraft has decreased, because it is seen that the number of flights has increased, and only the inclusion of other aircraft in the statistics changes the rates. Therefore, it may be recommended

that other aircraft types be taken into account in future studies in order for the results to provide a different perspective.

5.4 Application Data

After the aircraft types, numbers and LTO figures with known details, CO2 emissions during the cruise can be found. Therefore, the study was created according to the Tier 2 method determined by the IPCC and the monthly emission values of each type of aircraft were calculated. Based on the IPCC (2006) data, the sulfur dioxide emission rates caused by the aircraft types specified in Table 3 are shown. The source rates were taken from the fuel combustion emissions section of the topics collected under the title of "Energy" in the Intergovernmental Panel on Climate Change (IPCC) guide. Tier methods were prepared to be used to calculate factors such as combustion conditions, technology used, emission standards and fuel properties in emissions caused by the transportation sector.

The formula used in the Tier 1 method is given below:

Emission Amount = Emission Factor X Fuel Consumption

The Tier 2 method is only applied to jet engine aircraft using jet fuel. Therefore, in order to use this method, the LTO number and aircraft types must be known. The formula for this calculation method is given below:

LTO Emission = LTO number × LTO Emission Factor

Table 3

Emission Factors by Aircraft Types According to IPCC Data

AIRCRAFT TYPES	CO_2	CH_4	N_2O	NO_X	CO	NMVOC	SO_2	FUEL CONSUMPTION
B 737-800	2780	0,07	0,1	12,30	7,07	0,65	0,88	880
A 321	3020	0,14	0,1	16,72	7,55	1,27	0,96	960
A 320	2440	0,06	0,01	9,01	6,19	0,51	0,77	770

The emission rates for the specified flights, calculated using the Tier 1 and Tier 2 methods, are shown below in separate tables according to aircraft types.

Table 4

Emission Rates of Boeing 737-800 (2020-2023 Period, Ankara Esenboğa Airport)

BOEING 737-800				
PERIOD	2020	2021	2022	2023
LTO NUMBER	13.921	17.163	17.531	20.841
CO_2	38.700.380,00	47.713.140,00	48.736.180,00	57.937.980,00
CH_4	974,47	1.201,41	1.227,17	1.458,87
N_2O	1.392,10	1.716,30	1.753,10	2.084,10
NO_X	171.228,30	211.104,90	215.631,30	256.344,30
CO	98.421,47	121.342,41	123.944,17	147.345,87
NMVOC	9.048,65	11.155,95	11.395,15	13.546,65
SO_2	12.250,48	15.103,44	15.427,28	18.340,08

FUEL CONSUMPTION (KG/LTO)	12.250.480,00	15.103.440,00	15.427.280,00	18.340.080,00

Table 5

Emission Rates of Airbus A 321 (2020-2023 Period, Ankara Esenboğa Airport)

AIRBUS A 321				
PERIOD	2020	2021	2022	2023
LTO NUMBER	2.784	4.429	6.045	8.817
CO_2	8.407.680,00	13.375.580,00	18.255.900,00	26.627.340,00
CH_4	389,76	620,06	846,30	1.234,38
N_2O	278,40	442,90	604,50	881,70
NO_X	46.548,48	74.052,88	101.072,40	147.420,24
CO	21.019,20	33.438,95	45.639,75	66.568,35
NMVOC	3.535,68	5.624,83	7.677,15	11.197,59
SO_2	2.672,64	4.251,84	5.803,20	8.464,32
FUEL CONSUMPTION (KG/LTO)	2.672.640,00	4.251.840,00	5.803.200,00	8.464.320,00

Table 6

Emission Rates of Airbus A 320 (2020-2023 Period, Ankara Esenboğa Airport)

AIRBUS A 320				
PERIOD	2020	2021	2022	2023
LTO NUMBER	2.784	4.429	4.836	5.611
CO_2	6.792.960,00	10.806.760,00	11.799.840,00	13.690.840,00
CH_4	167,04	265,74	290,16	336,66
N_2O	27,84	44,29	48,36	56,11
NO_X	25.083,84	39.905,29	43.572,36	50.555,11
CO	17.232,96	27.415,51	29.934,84	34.732,09
NMVOC	1.419,84	2.258,79	2.466,36	2.861,61
SO_2	2.143,68	3.410,33	3.723,72	4.320,47
FUEL CONSUMPTION (KG/LTO)	2.143.680,00	3.410.330,00	3.723.720,00	4.320.470,00

When the tables are examined, it is seen that fuel consumption increases in the same proportion as the number of LTOs increases. When different aircraft types are added, it can be revealed with safer results which aircraft type will be relatively environmentally friendly compared to the LTO numbers. Another result is that aircraft with low emission rates also have low emission rates.

6. Conclusion and Discussion

When emissions from aircraft around the world are examined, it is seen that the most important of these effects is CO2 or carbon dioxide. While emissions negatively affect the environment, it should not be ignored that they also adversely affect human health and put the future at risk. In recent years, evaluating and controlling the negative effects of environmental factors has become one of the most important factors in managing climate change.

In particular, it is important to calculate the environmental costs arising from the activities, and opening sub-accounts within the scope of climate change management in the Uniform

Chart of Accounts will have a significant impact both on the correct calculation of costs and on the prevention of environmental damage. In addition, calculating environmental costs will minimize the costs incurred within the sectors and lead to an increase in environmental sensitivity. Therefore, encouraging sectors that are particularly related to the environment is an important step.

In the "Carbon Emission" calculation specified in the study, the 2020-2023 period of Ankara Esenboğa Airport, one of the busiest airports in Türkiye, was considered. In addition, the study includes evaluations according to the aircraft types in the top three in the ranking of the most used aircraft types at the relevant airport and the aircraft traffic. Continuous reports are published by authorized institutions in the civil aviation sector in Türkiye. In the light of these reports, it is seen that the most used commercial aircraft models in our country in recent years are Boeing 737-800 and Airbus A320. As a result of the examinations, it is also understood that aircraft types and flight numbers affect the emission values in the direction of increasing them. However, the main problem here is the applicability of the relevant calculations. In addition, when the reports are examined according to aircraft types, it is seen that the emission amounts of Airbus A 321 type aircraft are higher than other models. One of the main reasons for this can be explained by the fact that the relevant model has a larger body and more passenger capacity than other models. It is understood that the emission values of the Boeing brand aircraft, which are two models closer to each other, the Airbus A320 and the Boeing 737-800, are approximately 15% higher than its counterpart.

It is thought that the increased use of newer generation aircraft will contribute to the management of climate change in the context of the civil aviation sector by preventing the increase in emission values. In order to shed light on future studies, it should be considered what methods or aircrafts will be appropriate to use in order to reduce emission values due to the increasing importance of air transportation and the increase in the number of flights. In addition, considering that the continuous increase in the number of flights cannot be prevented, it can be suggested that other factors should be controlled. Among these suggested factors, it can be stated that the boarding and disembarkation times of passengers, the selection of more environmentally friendly fuels, the shortening of all airport service times provided to passengers, the use of operation management and tracking software, and the further reduction of weights in aircrafts. Currently, the applications in green certified airports should also be expanded to cover all airports.

Since the most used resource of aircraft is fuel, its effect on climate change is certain, and it is estimated that the use of new generation aircraft, biofuels and electric aircraft will increase in the coming periods. After all, the data at hand is only an investigation of the effects of 3 types of aircraft at an airport for a certain period of time. However, it reveals the importance of the aviation sector in understanding how strong the effects of even the smallest increase are. The development of separate methods other than the IPCC data method used as a calculation method and the complete implementation of the sanctions resulting from this data by all authorities should be seen as measures that will increase the real impact in managing climate change. Again in managing climate change, reduction measures should be implemented without delay regardless of sector. Because approximately 2.1% of all human-induced CO2 emissions are produced by the global aviation sector. As another calculation,

commercial aviation, namely air transportation, has a 12% share in CO2 emissions caused by all transportation routes (Air Transport Action Group, ATAG, 2021).

There are two basic limitations of the study. First, only Ankara Esenboğa Airport was taken as a sample as an airline company. The other limitation is that the data was analyzed according to three aircraft types (Boeing 737-800, Airbus A 321, and Airbus A 320) and aircraft traffic. In this respect, the obtained data is only valid for this study. In future studies; adding the same subject to the study with other airports and aircraft types or making a comparative analysis with international airports and presenting the accounting transactions in the prevention of emissions and the strategies applied in minimizing environmental damages and presenting it as a guide in eliminating the accounting deficiency in the context of Türkiye will contribute to the literature. The study is a recommendation for the researchers' future studies.

ACKNOWLEDGEMENT
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FUNDING
No financial support was received from any person or institution for the study.

ETHICS
The author declares that this article complies with ethical standards and rules.

AUTHOR CONTRIBUTION

İpek Yaylalı | General contribution rate: 50%.

Fatih Karaman | General contribution rate: 50%.

CONFLICT OF INTEREST
The author declares no conflict of interest.

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