8 (3): 347-356 (2024)

Journal of Aviation

https://dergipark.org.tr/en/pub/jav

e-ISSN 2587-1676

An Assessment of an Airline Company within the Scope of Circular Economy Based Waste Management

Sinem Büyüksaatçı Kiriş[1], Binnur Gürül[2*]

[1]Istanbul University-Cerrahpasa, Industrial Engineering Department, 34320, Istanbul, Türkiye. (s.buyuksaatcikiris@iuc.edu.tr)
[2 *]Istanbul Gelisim University, Industrial Engineering Department, Istanbul, Türkiye. (bgurul@gelisim.edu.tr)

Article Info

Received: 04 July 2024
Revised: 29 July 2024
Accepted: 26 August 2024
Published Online: 11 October 2024

Keywords:
Aviation
Airline industry
Circular Economy

Corresponding Author: *Binnur Gürül*

RESEARCH ARTICLE

https://doi.org/10.30518/jav.1509650

Abstract

The rapid growth in the aviation sector has prompted the industry to act and develop new and sustainable business models due to the greenhouse gases and waste generated inherently by the sector. In this context, this study provides an assessment of identifiable areas and determinants of circular economy in an airline company, considering its environmental impacts. As a result of the assessment, it has been observed that the airline company conducts initiatives in reduction, reuse, and recycling, along with the management of cabin materials and waste segregation. Action plans are in place regarding the reduction, substitution, or elimination of single-use plastics in material selection. In order to mitigate both the environmental and economic impacts of paper consumption, the company is undertaking digitalization efforts within its business processes. The weight of aircraft is a crucial factor in the amount of fuel consumed and the quantity of CO2 emissions released. Therefore, airlines prefer to use lightweight materials inside the aircraft to reduce weight. Plastic catering materials are among these lightweight options. Unfortunately, due to the adverse environmental impacts of plastics, reducing their usage and, if possible, phasing them out are essential measures that airlines need to take. Consequently, the airline company under this study has removed the plastic outer packaging of the packaged materials used in the cabin. Furthermore, it continues its efforts to remove plastic materials used during catering services or replace them with biodegradable alternatives.

1. Introduction

Our current economic model is based on the traditional linear economy model, which follows the production, consumption, and disposal of products. However, this unsustainable linear economic model leads to increasing pressure on limited resources and generates significant amounts of waste, pollution, and greenhouse gas (GHG) emissions. The linear economic model, which follows the take-make-consume-dispose approach (Jaeger and Upadhyay, 2020), encourages consumers to continually consume new products. Moreover, this approach yields products with short lifespans, unsustainable outcomes, and residual waste within the system post-consumption, while absolving producers of any responsibility regarding waste management. (Karamustafa et al., 2022).

The traditional production and consumption paradigm poses challenges to the environment, society, and the depletion of finite resources. Globally, consumption rates have increased eightfold over a few decades, and it is projected that global resource use would triple by 2050. The overuse of finite resources has led to environmental degradation reaching unsustainable levels. Cities with dense populations produce 1.3 billion tons of waste annually, and this figure is expected to rise to 2.2 billion tons by 2025 (Jaeger and Upadhyay, 2020).

Estimates suggesting that global consumption has exceeded the planet's capacity for self-renewal by 50% indicate that if unsustainable production and consumption patterns persist, the critical situation would worsen even further in the near future (Veral, 2019). Currently, meeting the needs of the world's population requires 1.75 Earths, and if current consumption and production patterns continue, it is estimated that by 2050, we would need the resources equivalent to three Earths to meet our needs (Global Footprint Network, 2023). As a result of all these negative developments, various driving forces such as customers, investors, regulatory bodies, and other stakeholders are urging companies, governments, and all other organizations to adopt more environmentally friendly practices for solving the problem.

In the circular economy model, which offers an alternative path to the current model, the aim is to maximize the value obtained from the resources used while also striving to keep materials circulating for as long as possible. Moreover, the objective is to minimize environmental and social impacts, reduce economic costs, and generate employment opportunities. In this manner, the circular economy model is building economic, natural and social capital (ICAO, 2024). The circular economy model, is defined as a clean production model where energy and all resources are used efficiently, waste is recycled through an integrated process, and product

and raw material reuse is facilitated, leading to almost zero waste formation (Veral, 2019). In the circular economy, the focus is on products re-entering the production line, thus giving producers responsibility for waste management by producing recyclable products (Karamustafa et al., 2022).

The measurement of the social and environmental impacts of companies' activities and how these metrics guide their business strategies and operations, shaping their business models considering these impacts, are among the focal points of today's society, investors, and customers. Companies are now being evaluated not only based on financial data but also on environmental and social metrics by their stakeholders. Impact stakeholders, both internal and external, prioritize understanding which environmental and social contributions lead to companies' economic successes. Sustainability now plays a crucial role in companies' long-term economic success. What is expected from companies is to determine the environmental and social impacts of their business strategies and models at both micro and macro levels and manage their outputs with a sustainable development model (PricewaterhouseCoopers, 2024).

Although the circular economy model proposes a production and management model for the manufacturing sector, there is still a significant lack of development of this model for the service sector. With the increasing momentum in air transportation and the time advantage offered by airlines, they have begun to emerge as one of the most significant players in the service sector in the 21st century. This has led to an increase in passenger capacity, routes, and destinations. However, at the current stage of passenger transportation, the growing number of passengers and destinations place significant responsibilities on airlines regarding the management of both emissions and waste. This encourages airlines to take responsibility for their activities by managing them through sustainable development. Despite the lack of a standardized circular model in the service sector, the circular economy seeks cleaner production and better management of resources. In this context, initiatives such as the adoption of more efficient materials and the reduction of raw materials through 3R (Reduce, Reuse, Recycle) and zero waste initiatives are becoming widespread across Airlines (Salesa et al., 2023). According to Dias et al. (2022), businesses can minimize environmental degradation while maximizing mutually beneficial results, improving brand image, growing market share, and increasing profitability by implementing circular economy concepts like 3R.

Studies on environmentally friendly strategies used in the aviation industry are available in the literature, with a focus on lowering waste's negative environmental effects, meeting legal obligations, minimizing energy consumption and concerning sustainable development. Baxter et al. (2018) investigated Kansai International Airport's waste management from 2002 to 2015 using a comprehensive case study approach. They presented both the annual waste data produced with the empirical data they obtained as a result of the document analysis and presented the changes in the waste amounts in various year intervals statistically with the quantitative data analysis they performed. Baxter and Srisaeng (2022) carried out a similar study for London Gatwick Airport.

Blanca-Alcubilla et al. (2020) performed a case study on Iberia, the Spanish airline's catering service. They concentrated on how reusing packaging and tableware could lower greenhouse gas emissions. Sarbassov et al. (2020) conducted a compositional analysis of the municipal solid waste generated at Astana International Airport with the aim of assessing the greenhouse gas emissions associated with four distinct waste management scenarios. The first scenario outlined the existing state of municipal solid waste management; the second included recycling in 29% of cases and landfilling in 71% of cases; the third scenario called for the complete incineration of municipal solid waste from airports. scenario 4 calls for processing the leftover waste for energy recovery and recycling 29% of it. An analysis of the effects of airport operations on carbon emissions at the macro and micro levels was given by Xiong et al (2023). During the years 1999–2017, 280 prefecture-level cities in China provided a total of 4938 datasets for study. The heterogeneity analysis was examined from several dimensions.

Günerhan et al. (2023) assessed the use of oil from waste tires in aviation gas turbines in terms of fuel properties, emissions, performance and combustion characteristics, considering that the need for alternative fuels in terms of sustainability and renewability. A study focusing on the use of plastic waste-based alternative oil for use in aircraft turbojet engines was also discussed by Lee et al. (2024). By using thermodynamic calculations, they assessed the created high density polyethylene derivative oils' suitability as aircraft fuels and compared them with a range of commercial aviation fuels.

Tjahjono et al. (2023) suggested a novel design approach for managing retail waste at airport terminals dubbed circular airport retail waste management (CAWM). The suggested approach was on the basis of the circular economy 9R framework and could handle waste from airport terminals more effectively and economically. A business process modeling system was created by Sukhorukov et al. (2023) to manage the plan for the collection, transfer, and disposal of municipal solid waste at Moscow Domodedovo Airport. The waste data produced in the cabin in 2019 was used by Guven et al. (2024) to illustrate the potential of Antalya Airport's international in-flight waste to produce valuable products such as fertilizer, energy.

Previous literature has focused on various themes in the aviation sector such as emission reduction, waste management, alternative fuel use, etc. Based on the literature review, further research is needed that evaluates the waste management mechanism of an airline company from many perspectives within the scope of circular economy.

This study focuses on a global airline company's waste management system and its incorporation of circular economy practices into the daily operations. The airline is operating international flights and covering a wide range of geographical areas due to the extensive network of its flight routes. The study examines the circular economy practices implemented by an airline using a framework based on the literature The methods employed by the airline to achieve better environmental performance are derived from responses obtained from relevant departments within the airline, sustainability reports of the airline, and publicly available sources. Based on the information gathered, the airline's performance in seven different categories was calculated and presented through a radar chart.

This study has given airlines operating in the Turkish aviation sector a framework to assess themselves and has added to the literature with the application carried out. The study calculates the airline's score for recycling, upcycling, or handling of various forms of waste and reveals its shortcomings. Therefore, in this respect, it is important as an example of waste management within the scope of the circular economy, which has been given importance by all businesses in recent years.

The structure of this paper is as follows: the next section presents general information about the circular economy. The third section highlights the importance of waste management in a circular economy. In the fourth section, waste

management is discussed specifically in the aviation industry. The fifth section explains the basic structure of the methodology in order to assess airline's performance. Finally, results and discussion are presented.

2. What Is Circular Economy?

Circularity has been the guiding principle of nature since the very beginning. The first humans lived in a circular society of scarcity and lack, driven by necessity, in many regions of the world that are still industrially less developed today. This was a non-monetary circular society. With the changing way of living, working and communicating in recent years, society, business world and governments realized that the "linear economy" that emerged in the early industrial revolutions was not financially, socially or ecologically sustainable, and instead, a new approach, the circular economy, emerged. Rather than producing value loss by discarding products and materials after use, the circular economy redesigns products, processes, supply networks, and business models to create, protect, and circulate value Reuse, repair, remanufacturing, and recycling are made possible by the creation of durable items and the recovery of products and resources after use. The "take-make-use-dispose" paradigm is changed into "value cycles" by circular economy strategies, which also replenish ecosystems and resources to produce more with less. (Weetman, 2020).

Preserving and managing the values of assets, such as natural, cultural, human, manufactured, and financial stocks, is the goal of the circular economy. The circular economy is considered the most sustainable post-industrial economy business model available (Stahel and MacArthur, 2019).

The definition of a circular economy is an economic model that seeks to limit the adverse effects of specific raw materials, goods, and assets on the environment while utilizing rational, effective, and efficient resources. Innovation, environmental protection and stewardship, competitiveness vis-à-vis the linear economy, sustainability and regenerative nature of products, raw material supply security, cost savings, improved quality of life, and stable economic growth based on sustainable development are the factors that define a circular economy (Rutkowski, 2022).

The "take-make-use-dispose" model of the linear economy is turning into a circular model at various levels; micro, meso (medium) and macro. At the micro level, environmental management systems are integrated with the reduction of resource use and emissions in a specific process or production facility. At the meso level, a group of manufacturing facilities or sectors may be included in an industrial park or industrial ecology-type system where unusable output from one can feed into another. The macro level includes the development of eco-cities. Unlike the micro and meso level, there are both production and consumption concerns at the macro level and the transformation is expressed at the level of the entire economy (Gheewala and Silalertruksa, 2021). In light of all this information, the circular economy substitutes material reduction, reuse, recycling, and recovery for the idea of "end-of-life" in production, distribution, and consumption processes. The circular economy, then, is an economic framework that operates at three different levels: micro (products, companies, and consumers), meso (eco-industrial parks), and macro (city, region, country, and beyond). Its goals are to create social equality, economic prosperity, and environmental quality for both present and future generations in order to achieve sustainable development. (Kirchherr et al., 2017).

Circulation of materials back into the system ensures that the value of the products is preserved, thus being a better alternative to the widespread linear economic model. The shift from a linear model to a circular model reduces the demand for both raw resource inputs and waste disposal. Natural resource use and waste disposal are two carbon-intensive activities that are closely linked to global warming. Therefore, the circular economy is considered a suitable mitigation strategy to address the issues of resource scarcity, waste management, and climate change. Moreover, the circular economy is seen not only as a viable climate change mitigation strategy but also as an enabler for achieving the Sustainable Development Goals - SDGs (Tuladhar et al., 2022).

Korhonen et al. (2018) demonstrated the win-win-win potential of the circular economy. They argued that the economic, environmental, and social facets of sustainable development are all enhanced by a flourishing circular economy. Additionally, they stated that, by honoring reproduction rates, the circular economy should employ natural ecosystem cycles as a model for economic cycles.

Circular economy type regulations of physical flows of materials and energy will reduce natural inputs to the system and waste and emissions from the system. Costs associated with resources, energy, waste, and emissions—such as additional expenses brought on by environmental laws, taxes, or trash and landfill management—will be decreased. There will be new market, business, and job prospects. Because the value contained in the materials will be used many times, and not just once, as is usually the case in the modern global economic system, the circular economy extends existing business or corporate environmental management systems by promoting cross-sectoral, cross-organizational and cross-life cycle material and energy cascades to achieve the highest possible economic value in resources. Therefore, circular economy is defined as an inter-organizational environmental and sustainability management (Korhonen et al., 2018).

3. Waste Management in Circular Economy

A significant percentage of the world's population is concentrated in urban areas. The large number of people living in urban areas has brought with it various problems such as inadequate water supply and sanitation, air pollution, traffic problems and increasing amounts of solid waste. Most of the population growth occurs in economically developing countries. Although many industrialized countries in Europe, North America and Asia have developed policies to reduce the amount of waste produced, there are still many countries that do not properly manage their solid waste and rely on open dumps for disposal (Diaz, 2017).

Emphasizing that there are some problems that need to be solved regarding solid waste management in developing countries, Diaz (2017) also stated some of the most critical needs as follows: A political will to deal with the problem (waste), a national policy, rules and regulations on solid waste management, adequate resource allocation to solve the problem, educational programs at all levels and, lastly but the most important, implementation of policies regarding the establishment of a circular economy model. Although the "circular economy concept" was formulated relatively recently, the concept is being discussed and tried to be put into practice by public and private sector actors in developing countries. However, most, if not all, developing countries are applying some principles of the circular economy in waste management through "resource recovery efforts".

Circular economy is defined as a closed-loop value chain. In this value chain, it is essential to collect waste through appropriate channels and send it to production units for reuse. Thus, the model ensures sustainability in production and environmental practices by preventing and reducing waste (Gedik, 2020). Aiming to close supply chain loops as much as possible, the circular economy aims to create a sustainable and zero-waste environment, and for this it focuses specifically on the waste hierarchy, from waste prevention at the top to disposal at the bottom. An appropriate waste management system ensures that discarded, worn and/or old products are collected so that they are not left in nature and do not pollute the environment. In addition, such a waste management system ensures that waste is handled appropriately to facilitate re-intake into the system, thus avoiding the extraction of primary materials. Therefore, supporting environmental sustainability, human health, and the shift from a linear to a circular economy all depend on effective waste management. (Ranjbari et al., 2021).

Circular economy is defined as the most sustainable business model for the post-production process. It uses natural, human, cultural and produced stocks to improve the ecological, social and economic factors that create sustainability. "Greening Industry" concepts such as Industrial Ecology and Industrial Common Lives involve the reuse of waste from production processes within a linear industrial economy. These concepts reduce environmental degradation and increase the economic efficiency of production while managing production waste. While waste prevention is part of optimizing the use of objects in the circular industrial economy, waste management is the final stage of the linear industrial economy (Stahel and MacArthur, 2019).

4. Waste Management in Aviation Industry

The airline industry is one of the industries, that is noisy in nature, contributes to climate change with its waste, carbon dioxide (CO_2), NOx and other GHG emissions and causes many environmental problems. In addition to GHG, which are the most important factor in climate change, one of the main problems for the airline industry is the large amounts of waste produced during its operations (Alkhatib and Migdadi, 2021).

According to the research conducted by the Intergovernmental Panel on Climate Change (IPCC), the global airline industry is responsible for 12% of CO_2 emissions from all transportation sectors and produces approximately 2.1 % of human-induced GHG emissions that cause climate change (ATAG, 2024).

Considering the climate crisis and the effects of the airline industry, with increasing environmental awareness in recent years, the airline industry been forced intensify its efforts associated with all aviation activities and operations on consumption, waste and emissions towards a greener, cleaner and more sustainable aviation by reducing the environmental impacts. The aviation industry's potentially large environmental impact in terms of handling hazardous and non-hazardous waste needs to be addressed by developing and subsequently managing more sustainable environmental practices. Airlines are striving to modernize their outdated waste management systems and recovery processes and are rapidly implementing a wide range of measures to keep environmental impacts to a minimum (Migdadi, 2018).

The airline industry carries out various environmental practices and policies in order to minimize its negative environmental impacts. Alkhatib and Migdadi (2021) divided the environmental actions and indicators carried out by airlines into three main areas. These are operational, environmental and corporate actions.

1. Operational category/area: This includes actions such as route optimization, flight procedure optimization, air traffic management, weight reduction, reduction of use of auxiliary power units (APU), reduction of fuel management, ground operations, waste prevention, CO_2 offset programs, online check-in, reducing flight delays, engine flushing and reducing aircraft weight.
2. Environmental category/area (GHG emissions actions): It includes energy saving in facilities and buildings, sustainable energy use, improvement and replacement of facilities, vehicle and engine operation, maintenance management, recycling, upcycling and recycling of industrial and hazardous waste in aircraft and on the ground, waste management practices such as reuse and water management studies, maintenance, recycling, saving and recovery of facility and building water.
3. Corporate policies and strategies category/area: It includes applications related to the design of vehicles and engines such as aircraft designs, fleet modernization, use of winglets and sharklets, engine modifications and alternative biofuels, electric vehicles in land operations and renewable energy fueled equipment.

Although the circular economy is a developing concept for the aviation sector, the implementation of many circular economy practices in the sector already provides the sector with valuable environmental, social and economic opportunities. Stating that aviation is a sector that expects significant growth, ICAO (International Civil Aviation Organization) expects annual world air traffic to double by 2035 and the sector to grow at an average annual rate of 4.4 percent. According to Boeing and Airbus, the estimate of new aircraft delivered by 2034 will be 38,050 and 32,585 respectively. While all these predictions point to a potential increase in resource consumption, waste and emission production in global aviation, they underline how important the transition from a linear economy to a circular economy is for the sector in terms of contributing to the reduction of negative environmental impacts and associated economic costs (ICAO, 2023). Circular economy principles would enable the transition to circular aviation by creating a framework for re-evaluating the life cycle of every aspect of aviation with a complete, cradle to cradle understanding.

The application of circular economy principles to the aviation sector focuses on three elements: aircraft, flights and airports. The circular economy strategies adopted by airlines in their flight operations include four components of the circular economy as follows (ICAO, 2023):

- Redesign: Redesigning food services to properly separate waste;
- Reduce: Reducing the mass of food packaging and switching guidelines from hard copy to digital;
- Reuse: Reuse of seats and in-car entertainment systems in other systems;
- Recycle: Recycling reusable equipment such as trays, carrier drawers, blankets and serving carts.

In addition to managing GHG emissions for airlines, another top priority issue is waste management. Waste management in airlines is addressed by directly assessing the content of the airlines' activities. Considering the direct fields of activity, airlines generate waste such as in-flight packaging, paper, textiles, etc. as well as food waste and waste resulting from regular maintenance and use of aircraft.

Concretely, the types of waste resulting from the regular maintenance and use of aircraft are managed by airports or maintenance companies. Therefore, two types of waste are addressed directly in connection with the activities of airlines, which are food waste and other waste (from cabin and ground operations). Other waste includes many different products such as packaging, paper, textile and plastic, and hygienic waste types. It is stated by some researchers that in-cabin waste is the most common type waste for airlines worldwide and 70% of such waste is generated by passengers. On the other hand, food waste resulting from the feeding of passengers and cabin crew is defined as a priority problem by an increasing number of associations and governments due to food waste and the high pollution level it brings (Salesa et al., 2023).

National waste management regulations that reduce pollution apply to all in-flight waste, including newspapers, paper towels, plastic packaging from headphones and blankets, and residual food and drink packaging. (Aviationbenefits, 2023). The International Catering Waste (ICW) regulations, which have been enacted by numerous nations, are the main barrier to airlines' efforts to reuse and recycle more cabin waste. These regulations require international catering trash to follow certain procedures in an effort to lower the danger of plant and animal disease transmission (IATA, 2020).

Many country regulations impose strict controls on food waste from international flights based on animal welfare concerns. Rules formulated to prevent international transmission of certain diseases require airlines to treat food waste as high risk or burn it or bury it in deep landfills, preventing reuse and recycling (Aviationbenefits, 2023). On overseas flights, these stringent regulations prohibit airline food and cabin supplies from being reused or recycled. Cabin waste inspections carried out by IATA and airlines have shown that 20-25% of cabin waste consists of food and beverages not consumed by passengers or cabin crew. Although the volume of in-flight catering decreased during the pandemic, the industry burned or threw away 2-3 billion dollars of resources. While rules limit the industry's capacity to support the Sustainable Development Goals (SDGs), which seek to halve global food waste by 2030, and assist create a circular economy, airlines and catering providers can still reduce cabin waste via improved planning and logistics. (IATA, 2022).

Due to relevant regulations, estimating the approximate amount of food needed to satisfy each passenger's needs and cut down on extra stock is the greatest strategy to improve the efficiency of food products. In order to estimate the amount of food supply needed to meet passenger needs, airlines have started to develop new forecasting algorithms based on artificial intelligence and passenger behavior. Airlines would have precise knowledge of the required amount of meals if meal reservation systems were in place, greatly minimizing wastage. (Salesa et al., 2023).

5. Material and Method

Despite the fact that airlines adopt a variety of steps to carry out the circular economy assumptions (Asmatulu et al., 2013; Blanca-Alcubilla et al., 2020; Sarbassov et al., 2020; Domone et al., 2021; Baxter & Srisaeng, 2022; Dolganova et al., 2022; Markatos & Pantelakis, 2022; Tjahjono et al., 2023; Sukhorukov et al., 2023; Guven et al., 2024; Yang et al, 2024), studies are not yet considered sufficiently the implementation of effective and sustainable practices in flight and ground operations. Therefore, the practices carried out by airlines in order to transition to a circular economy are still open to evaluation. Based on this foresight, in this study, a single case study method was employed by incorporating survey form to collect and analyze empirical data to examine the waste management performance of an airline within the scope of circular economy.

The airline operates international flights, and has operations in many different geographies thanks to the wide flight network. The circular economy practices adopted by the airline to improve waste and material management were examined based on the analysis and classification of specific sustainable practices developed by Salesa et al (2023). The waste and material management practices developed by Salesa et al (2023) and which form the basis of this study, consist of 7 global categories and 23 general initiatives that serve as a reference to focus only on activities related to the circular economy. Table 1 provides descriptions of these 7 categories and 23 general initiatives. Under general initiatives, there are a total of 58 identifiable, circular economy-oriented sub-headings. These were shown in Appendix.

Table 1. Hierarchy of Initiatives

C1. Onboard and ground waste recycling
1. Recycling tracking system
2. Internal auditing in recycling
3. In-cabin waste management system
4. In-cabin material recycling
5. Recycling paper
6. Recycling plastic
7. Recycling cans
C2. Onboard and ground waste upcycling
8. Outdated uniforms to manufacture in-flight products
9. Stuff clothing repurposed
10. Eco-friendly materials
11. Plans to remove plastic
12. New product design reusability
13. New product design reparability
C3. Reducing the use of paper
14. Electronic airway bills
15. Using electronic boarding passes
16. Providing iPads/tablets to reduce paper
C4. Upcycling industrial waste
17. Burning waste to recover energy
C5. Processing hazardous waste
18. Recycling hazardous waste
19. Tracking systems
C6. Upcycling hazardous waste
20. Burning hazardous waste
C7. Food waste management
21. Food stock prediction and eco-friendly packaging
22. Food waste management
23. Food eco-friendly packaging

The information about the airline's circular economy practices based on Table 1 was obtained directly from the relevant respondents in the airline, from the Sustainability Reports published by the airline between 2022-2023, and from information published in public sources. Table 2 includes information about the 4 respondents, who work at the airline company and whose information was consulted. We made sure that the respondents were chosen based on their extensive work background with the airline.

While collecting information from the relevant respondents, a survey form was presented, which included 58 sub-headings of the 7 global categories content prepared by

Table 2. Profiles of the respondents

Respondent #	Department	Position	Experience (Years)
Respondent 1	Sustainability Department	Sustainability Specialist	>10
Respondent 2	Sustainability Department	Corporate Sustainability Specialist	>5
Respondent 3	Waste Management Department	Department Chief	>10
Respondent 4	Catering Department	Specialist	>5

Salesa et al. (2023). Then the participants' response to the implementation status of each subheading were obtained in the following categories:

- Implemented: The initiative is implemented by the airline in all operations and processes.
- Partially Implemented: The initiative has started to be implemented in the airline, but its scope does not yet cover all activities/locations/processes.
- Not implemented: The initiative is not implemented by the airline.
- To be implemented: The initiative has been approved by airline management but has not yet been implemented.

Although many subheadings were answered directly by respondents, the answers were also confirmed with secondary data obtained from sustainability reports shared with the public or other published sources.

6. Result and Discussion

The level of adoption of the applications in the framework in Table 1 by the airline considered in this study is calculated and shown with a radar chart presented in Figure 1. If the subheadings under each category are implemented, they are scored equally, totaling 100 points; in partial implementations, half of this score is taken; in cases of non-implementation or to be implementation, no score is assigned to the subheading. For example, there are 20 subheadings under category C1, and if the implementation of these headings is in question, each one received 5 points. “No plastic bags for in cabin purchases”, “Using the mobile devices and tablets to the cabin crew to make whole snacks and meals sells processes”, “Receipts from in-flight purchases are send through the app not requiring a ticket printing” were excluded from the evaluation, because there are no in-flight sales in the airline.

The airline focuses heavily on initiatives such as recycling plastic, paper and cans, integrates an internal recycling tracking system into its business models to track how waste is managed and uses new environmentally friendly materials to replace these “hard to recycle” elements. Regarding to “C1: Onboard and ground waste recycling”, it has been found that the airline has developed systems to monitor waste management and is working to promote the 3Rs (Reduce, Reuse, Recycle) within the organization. With its regular monitoring systems and regular inspections arising from legal regulations, the airline not only monitors the regular functioning of waste separation practices but also ensures the control of storage areas and inspections of sites. Another notable practice in the airlines is the management and recycling of waste in the cabin. In this context, waste in the cabin is separated and recycled during the flight, and training is given to the cabin crew on how to manage these wastes correctly.

Rather than recycling paper, the airline also prevents the use of paper with the new products and systems it develops. In particular, the development of electronic document correspondence systems prevents the use of paper. At the same time, for plastics, it offers products without plastic outer packaging within the scope of plastic prevention and takes initiatives to replace plastic products with substitute products. In line with all this information, the score the airline received for the “C1: Onboard and ground waste recycling” category was calculated as 90.

“C2: Onboard and ground waste upcycling” shows the airline’s key practices for recycling waste. Focusing on using ecological materials, the airline uses biodegradable materials instead of materials that cannot be easily recycled. On the other hand, there appears to be a high movement focusing on reducing and eliminating the use of plastic in flights and ground operations. In the airline, practices are carried out to avoid the use of products that may harm the environment and to reduce plastics. At the same time, introducing bamboo and other plant materials for some daily-used materials, especially on flights, is among the airline’s upcoming projects. In general, the airline reduces the amount of plastic used, but also implements some special practices. These practices include presenting plastic-free packaging in order to eliminate single-use plastics, replacing products made of plastic materials with biodegradable products among the products distributed in the cabin, replacing plastic cutlery with products made of different materials, reducing resource use by ensuring that materials are used more than once and outdated products, applications reusing uniforms to produce different products and ensuring that the materials inside the aircraft are made of easily repairable materials to increase the life cycle of the products.

“Introducing vegetal alternatives to pollutant materials”, “inclusion of materials like bamboo and others replace plastic single-use elements”, “reduction of the plastic present in packaging by eco-designing it” and “removing any plastic cup by compostable cups made with bio elements” were evaluated under the C2 category. However, these were considered to be implemented by the airline company and therefore no points were given during the evaluation phase. Accordingly, the airline's evaluation score was low in this category, at 40.93.

The airline is implementing many of the nine key practices that contribute to three different initiatives within the “C3: Reducing the use of paper” category. Applications related to in-flight product sales under the category were excluded from evaluation since they do not fall within the scope of the airline’s activities. Works are being carried out to digitalize the normal workflow in order to reduce paper use in the airline. As part of the complete digitalization of mandatory flight documents, the use of printed documents has been terminated. In this context, tablets are provided to flight crews so that they can both make reports and access flight documents. Another application implemented to reduce paper use is the digital boarding process. Airline applications are being developed to fully digitize boarding passes. At the same time, magazines offered to passengers on the plane have been moved to digital media, the contents have been enriched and airline magazines have been removed. The score the airline received in this category was calculated as 71.44.

The “C5: Processing hazardous waste” category shows the key practices implemented by the airline to recycle and upcycle hazardous waste. There are not many specific practices for managing hazardous waste. However, the airline company sends all hazardous waste to expert processors and ensures that the waste is disposed of in accordance with all

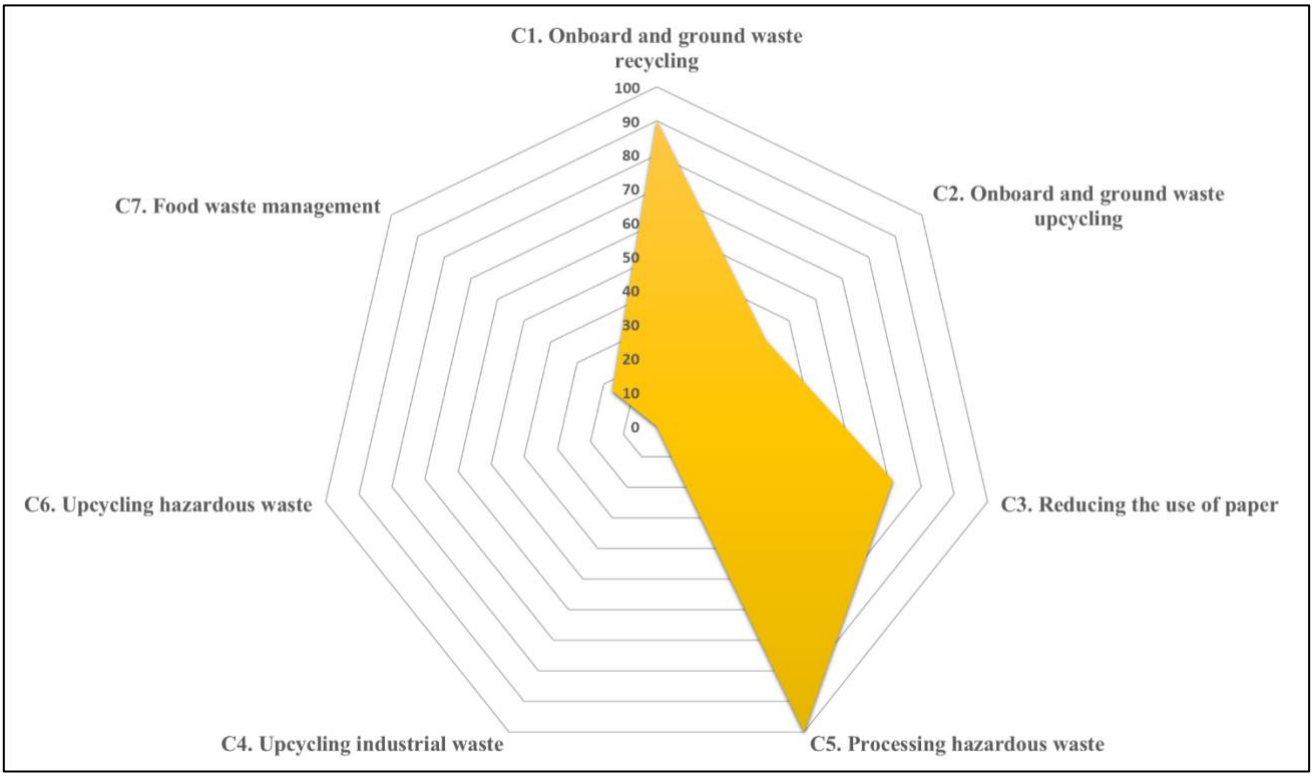

Figure 2. If authors want to put the figures as above, please do as above.

legal regulations. In line with all these practices, the airline received a full score (100) in this category.

Since incineration of waste for energy gain, which is in the categories "C4: Upcycling industrial waste" and "C6: Upcycling hazardous wastes", has not yet been implemented in the airline, these categories received the lowest value with 0 points in the chart.

Finally, regarding the management of food waste, the "C7: Food waste management" category summarizes the key practices adopted by the airline. The applications discussed in this category consist of applications that focus on reducing the amount of food carried on each flight and reducing the negative impact of its packaging. When the applications are evaluated, the applications that will be implemented by the airline in the near future to reduce food waste are stated. However, since these applications have not been implemented yet, no points were given, and under this category, the airline received 16.67 points, which was evaluated lower than other categories, as can be seen from the radar chart. Increasing food waste as a result of the airline's general practices have caused the airline to change its strategy. The airline is working to improve the flight meal reservation system in order to prevent increasing food waste. The airline also develops collaborations with the aim of reducing menu cards and switching to sustainable alternatives in food packages. On the other hand, the issues of ensuring the reusability of cutlery sets used in airline flights by making them from biomaterials and changing the traditional presentation of refreshments with ecological packaging have not yet been addressed by the airline.

In general, in order to accelerate its transition to a circular economy, the airline primarily adopts the reduction of waste where it cannot prevent its generation. Thus, the airline states that it acts on the principle of bringing waste back into the economy through recycling processes. Despite the implemented practices and measures taken, unavoidable waste is sent for disposal by the airline through licensed companies in accordance with environmental legislation.

7. Conclusion

The airlines have been developing sustainability strategies for a long time and taking precautions in this context in order to reduce their negative impact on the environment. With these measures, which they call cleaner and greener, they implement various circular economy practices in order to reduce both natural resource consumption and waste. These practices increase the sustainability performance of airlines and facilitate their transition to a circular economy.

There is still a need for improvement in this regard in the airline industry due to the lack of a specific model for all companies in the service sector, the high investment levels for the transformation of systems, and the limitations of the circular economy model in the service sector. Although there are studies in the literature that statistically analyze various types of waste in airlines (Baxter et al., 2018; Baxter and Srisaeng, 2022), evaluate carbon emission levels with different waste management practices (Blanca-Alcubilla et al., 2020; Sarbassov et al., 2020; Xiong et al., 2023), examine the use of alternative fuels in aviation gas turbines (Günerhan et al., 2023; Lee et al., 2024), and ensure that waste generated in airline terminals is managed effectively and economically within the scope of the circular economy (Tjahjono et al., 2023; Sukhorukov et al., 2023; Guven et al., 2024), a study has not been conducted in which an airline company would score and evaluate itself in terms of different types of waste within the perspective of the circular economy.

In this regard, within the scope of this study, through a case analysis conducted in an airline company, points open to improvement within the scope of circular economy based waste management were tried to be identified. In the study, the practices carried out by the airline for recycling, upcycling or processing of various forms of waste are evaluated according to whether they are implemented, partially implemented, not

implemented or to be implemented, and the shortcomings are revealed in line with the calculated scores.

It is clear that the airline has many practices in waste recycling, reducing paper usage, and handling hazardous waste. However, there is currently no application for upcycling industrial and hazardous wastes to generate energy. Significant advancements in these aspects of aviation are necessary.

The issue of food waste is already a controversial issue in the airline industry, but it is a difficult area to manage. Given that food waste is organic waste, many nations have put in place stringent regulations to safeguard national wildlife or public health. Managing food waste requires extra effort as restrictions vary from country to country and often requires further transfer to processing and incineration. Due to these issues, businesses are starting to develop substitutes that would cut down on food waste and food packaging waste at the source. For this reason, meal reservation systems are often used in airlines (IATA, 2022). In the airline company under study, while recycling of cooking oils into biodiesel and provision of napkins made from recycled materials upon request are implemented, there exist numerous other practices that could be undertaken within the framework of the circular economy.

This study is well-suited to support efforts in the service industries aimed at implementing circular economy practices. Through this structured narrative, the study aspires to make a substantial contribution to the field of aviation, providing airlines with a robust approach for waste management. Undertaking similar initiatives in other service sectors will establish the foundation for future studies and enable the framework under consideration to be generalized. The research also aims to bridge the gap between theoretical models specific to the circular economy and real-world applicability.

Appendix

Table 1. Hierarchy of Initiatives

C1. Onboard and ground waste recycling

1. Recycling tracking system
   - Waste management tracking system
   - 3Rs diffusion through the organization
   - Identification of types and sources of waste
   - Frequent monitoring
2. Internal auditing in recycling
   - Landfills periodically checked
   - Waste storage sites' inspections
   - Records of waste managed
3. In-cabin waste management system
   - Teaching cabin crew to properly manage waste
   - Amenities on demand
   - Redesign of daily elements the use less quantity of raw materials
   - Reduce the number of basic products to reduce waste
   - Separate hazardous waste from non-hazardous to facilitate sorting
4. In-cabin material recycling
   - Waste sorting in-cabin segregating during the flight
   - Promotion of recycling to passengers and cabin crew
   - Full recovery of reusable in-cabin items
5. Recycling paper
   - "Expired magazines" are fully recycled
   - Specific spaces for paper and cardboard storage
6. Recycling plastic
   - Collection and transfer of PET Waste to further disposal
   - Implementing new recycling methods to foster plastic recovery
7. Recycling cans
   - Collection of every aluminum can from in-flight services

C2. Onboard and ground waste upcycling

8. Outdated uniforms to manufacture in-flight products
   - Old-fashioned, deprecated and highly used uniforms clothing use to apparel amenities
9. Stuff clothing repurposed
   - Napkins and table clothes from old uniforms
10. Eco-friendly materials
   - Biodegradable products to replace the materials difficult to recycle
   - Introducing vegetal alternatives to pollutant materials
   - Removing some elements that can be harmful for the environment
   - Fostering programs like bring your own cup and bottle by a discount
   - Collaborating with several institutions to design effective and efficient materials with specific conditions
11. Plans to remove plastic
   - Inclusion of materials like Bamboo and others to replace plastic single –use elements
   - Single use plastic reduction programs
   - Cutlery and food complements are removing the single use plastics
   - Designing in-flight strategies to reduce plastic
   - Reduction of the plastic present in packaging by eco-designing it
   - Removing any plastic cup by compostable cups made with bio elements
   - Reuse of plastic elements commonly used by the cabin crew (plastic rollers on IDs and paper tickers)
   - Unavoidable plastic used is used un plants to produce synthetic crude oil
   - No plastic bags for in cabin purchases
12. New product design reusability
   - Initiatives to invest in reusable a disposable new product instead
   - Removable parts on single use elements to divide hazardous from non-hazardous waste and easier the recycling process
   - Some plastic elements are used to produce synthetic crude oil
   - Items made with biodegradable materials are transformed into compost after the lifetime
13. New product design reparability
   - Whenever it is possible giving the elements more than one use to reduce the amount of items required
   - New eco cups easily removable and stackable to easier the management capacities
   - Furniture is made with easily repairable design to facilitate the reparability and increasing elements lifecycle

C3. Reducing the use of paper

14. Electronic airway bills
   - Total digitalization of mandatory flight documentation to reduce the use of paper and the weight
   - App-based reporting platform for cabin crew
   - Used of platforms to fully digitalize and automate the regular workflow
15. Using electronic boarding passes
   - Development of airlines apps to fully include the digital boarding process
   - Using only electronic boarding passes and charging an additional cost to people who wants printed passes
16. Providing tablets to reduce paper

- Pilots are provided with tablets to have all the information centralized and reducing the amount of paper required
- Replacing airlines magazines by tablets, reducing the paper use and making the content dynamic and more attractive
- Using the mobile devices and tablets to the cabin crew to make whole snacks and meals sells processes
- Receipts from in-flight purchases are send through the app not requiring a ticket printing

C4. Upcycling industrial waste

17. Burning waste to recover energy
    - Burning waste according to regulations whenever is not possible to be recycled to produce energy

C5. Processing hazardous waste

18. Recycling hazardous waste
    - Hazardous waste is properly dispose to comply all regulatory requirements
    - Hazardous waste is sent to specific and specialized handers to be properly processed
19. Tracking systems
    - Hazardous waste is sent to special plants to be managed according to countries regulation
    - Long-term collection plants to securely process potentially dangerous resources

C6. Upcycling hazardous waste

20. Burning hazardous waste
    - Generate energy from burning hazardous waste. According to international regulations whenever is not possible to be recycled or securely disposed

C7. Food waste management

21. Food stock prediction and eco-friendly packaging
    - Incorporation of a meal booking system to reduce food waste
    - Continuous food stock adaption using a prediction system to forecast the required amount of food
    - Reduction of the amount of "easy cooking" meals available to demand on flights
    - Reduction of the snacks and beverage catalogue
22. Food waste management
    - Agreements with suppliers to produce meals packaging in a sustainable manner
    - Recycling cooking oil to produce biodiesel
23. Food eco-friendly packaging
    - Reusable dishes and cutlery made with biomaterials
    - Napkins and amenities made from recycled materials and given on demand
    - Removing the traditional presentation of snacks for alternative ecological packaging made specifically for flight travels

Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

References

Alkhatib, S. F., & Migdadi, Y.K.A.A. (2021). A novel technique for evaluating and ranking green airlines: Benchmarking-base comparison. Management of Environmental Quality: An International Journal, 32(2), 210-226.

Asmatulu, E., Twomey, J., & Overcash, M. (2013). Evaluation of recycling efforts of aircraft companies in Wichita. Resources, Conservation and Recycling, 80, 36-45.

ATAG. (2024). Retrieved from ATAG: https://www.atag.org/facts-figures/ [Access Date: March 2024].

Aviationbenefits. (2023). Retrieved from Aviation Benefits Beyond Borders: https://aviationbenefits.org/ [Access Date: October 2023].

Baxter, G., Srisaeng, P., & Wild, G. (2018). Sustainable airport waste management: The case of Kansai international airport. Recycling, 3(1), 6.

Baxter, G., & Srisaeng, P. (2022). Optimizing airport sustainable waste management from the use of waste-to-energy technology and circular economy principles: The case of London Gatwick Airport. Int J Traffic Transp Eng, 12, 176-195.

Blanca-Alcubilla, G., Bala, A., de Castro, N., Colomé, R., & Fullana-i-Palmer, P. (2020). Is the reusable tableware the best option? Analysis of the aviation catering sector with a life cycle approach. Science of the Total Environment, 708, 135121.

Dias, V. M. R., Jugend, D., de Camargo Fiorini, P., do Amaral Razzino, C., & Pinheiro, M. A. P. (2022). Possibilities for applying the circular economy in the aerospace industry: Practices, opportunities and challenges. Journal of Air Transport Management, 102, 102227.

Diaz, L.F. (2017). Waste management in developing countries and the circular economy. Waste Management & Research, 35(1), 1-2.

Dolganova, I., Bach, V., Rödl, A., Kaltschmitt, M., & Finkbeiner, M. (2022). Assessment of critical resource use in aircraft manufacturing. Circular economy and sustainability, 2(3), 1193-1212.

Domone, J., Bliss, P., & Copus, M. (2021). A circular economy for civil aerospace. ATKINS-Member of the SNC-Lavalin Group.

Gedik, Y. (2020). Döngüsel ekonomiyi anlamak: Teorik bir çerçeve. Turkish Business Journal, 1(2), 110-137.

Gheewala, S. H., & Silalertruksa, T. (2021). Life cycle thinking in a circular economy. In: An Introduction to circular economy (pp.35-53). Springer International Publishing.

Global Footprint Network: https://www.footprintnetwork.org/our-work/earth-overshoot-day/ [Access Date: September 2023]

Gunerhan, A., Altuntas, O., & Caliskan, H. (2023). Utilization of renewable and sustainable aviation biofuels from waste tyres for sustainable aviation transport sector. Energy, 276, 127566.

Guven, T. B., Degirmenci, H., Gunerhan, A., & Altuntas, O. (2024). Energy efficiency and sustainability: Implementing circular economy principles for cabin waste management in aviation. Energy for Sustainable Development, 81, 101515.

IATA (2022). Sustainable Cabin: Cabin Waste and Single Use Plastics (SUP). https://www.iata.org/en/iata-repository/pressroom/fact-sheets/fact-sheet---cabin-waste/: IATA [Access Date: November 2022].

IATA (2020). Retrieved from: https://www.iata.org/en/programs/environment/cabin-waste/ [Access Date: November 2023].

ICAO. (2023). ICAO Environment Report Chapter Eight Towards a Circular Economy, https://www.icao.int/environmental-protection/Documents/EnvironmentalReports/2019/EN

VReport2019_pg275-278.pdf. [Access Date: 23 December 2023].

ICAO. (2024). Retrieved from ICAO: https://www.icao.int/environmental-protection/Pages/CircularEconomy.aspx [Access Date: February 2024].

Jaeger, B., & Upadhyay, A. (2020). Understanding barriers to circular economy: cases from the manufacturing industry. Journal of Enterprise Information Management, 33(4), 729-745.

Karamustafa, E.Y., Arsan, B., & Beşoğul, K. (2022). Döngüsel ekonomi ve endüstri 4.0'ın sürdürülebilir kalkınma hedeflerini gerçekleştirmeye etkisi: Sistematik literatür taraması. Bilgi Sosyal Bilimler Dergisi, 24(2), 294-323.

Kirchherr, J., Reike, D., & Hekkert, M. (2017). Conceptualizing the circular economy: An analysis of 114 definitions. Resources, Conservation and Recycling, 127, 221-232.

Korhonen, J., Honkasalo, A., & Seppälä, J. (2018). Circular economy: The concept and its limitations. Ecological Economics, 143, 37-46.

Lee, T., Jung, S., Lee, S., Tsang, Y. F., Lee, K. H., & Kwon, E. E. (2024). Production of aviation fuel via thermal cracking of plastic waste. Energy Conversion and Management, 315, 118827.

Markatos, D. N., & Pantelakis, S. G. (2022). Assessment of the impact of material selection on aviation sustainability, from a circular economy perspective. Aerospace, 9(2), 52.

Migdadi, Y.K.A.A. (2018). Identifying the best practices of airlines' green operations strategy: A cross-regional worldwide survey. Environmental Quality Management, 28(1), 21-32.

PricewaterhouseCoopers. (2024). Retrieved from PWC: https://www.pwc.com.tr/esg-ve-surdurulebilirlik [Access Date: February 2024].

Ranjbari, M., Saidani, M., Esfandabadi, Z.S., Peng, W., Lam, S.S., Aghbashlo, M., ... & Tabatabaei, M. (2021). Two decades of research on waste management in the circular economy: Insights from bibliometric, text mining, and content analyses. Journal of Cleaner Production, 314, 128009.

Rutkowski, M. (2022). The areas of impact of the circular economy in passenger air transport. In: Intelligent Solutions for Cities and Mobility of the Future 17 (pp.123-132). Springer International Publishing.

Salesa, A., León, R., & Moneva, J.M. (2023). Airlines practices to incorporate circular economy principles into the waste management system. Corporate Social Responsibility and Environmental Management, 30(1), 443-458.

Sarbassov, Y., Venetis, C., Aiymbetov, B., Abylkhani, B., Yagofarova, A., Tokmurzin, D., ... & Inglezakis, V. J. (2020). Municipal solid waste management and greenhouse gas emissions at international airports: a case study of Astana International Airport. Journal of Air Transport Management, 85, 101789.

Stahel, W.R., & MacArthur. E. (2019). The Circular Economy: A User's Guide. Routledge Publishing Limited.

Sukhorukov, A., Koryagin, N., Bogdanova, E., & Zakharova, E. (2022, October). Modeling of Sustainable Business Processes of Solid Municipal Waste Removal in Civil Aviation. In Proceedings of 10th International Conference on Recent Advances in Civil Aviation (pp. 433-443). Singapore: Springer Nature Singapore

Tjahjono, M., Ünal, E., & Tran, T. H. (2023). The circular economy transformation of airports: an alternative model for retail waste management. Sustainability, 15(4), 3860.

Tuladhar, A., Iatridis, K., & Dimov, D. (2022). History and evolution of the circular economy and circular economy business models. In: Circular economy and sustainability (pp.87-106). Elsevier Publishing.

Veral, E. S. (2019). An evaluation on the circular economy model and the loops design in the context of waste management. European Journal of Science and Technology, (15), 2019, s. 18-27, DOI: 10.31590/ejosat.479333.

Weetman, C. (2020). A circular economy handbook: How to build a more resilient, competitive and sustainable business. Kogan Page Publishers.

Xiong, X., Song, X., Kaygorodova, A., Ding, X., Guo, L., & Huang, J. (2023). Aviation and carbon emissions: Evidence from airport operations. Journal of Air Transport Management, 109, 102383.

Yang, C. H., Kuo, L., Liu, Y. Y., & Pan, K. L. (2024). Incorporating resource optimization for sustainable airline service innovation business decision model: toward circular economy policy achievement. Annals of Operations Research, 1-27.

Cite this article: Buyuksaatci Kiris, S., Gurul, B. (2024). An Assessment of an Airline Company within the Scope of Circular Economy Based Waste Management Journal of Aviation, 8(3), 347-356.