

RESEARCH ARTICLE



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Airlines practices to incorporate circular economy principles into the waste management system

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Abstract

Airlines' negative impacts are rising due to the growth of the industry, and therefore new and more sustainable alternative business models are being developed and implemented. In this context, this paper analyses how airlines are incorporating Circular Economy (CE) into their service model and proposes a framework to identify the main practices of CE that support waste management. After a detailed review of the corporate social responsibility (CSR) reports of a worldwide sample of companies, this paper builds on waste and material management, where airline activities have more impacts on edible and inedible waste. Results show that companies are adopting measures such as recycling in-cabin waste, incorporating new materials, and defining new systems to make the feeding services more efficient. Nevertheless, CE adoption is still low, and the CE strategies do not seem to follow specific patterns.

KEYWORDS

airlines, circular economy, circularity, environmental performance, service industry, waste management

JEL CLASSIFICATION

Q50, Q53, Q56

1 | INTRODUCTION

Researchers worldwide are trying to define CE as a new economic model. Nowadays, several definitions are being proposed to fulfil the lack of a globally accepted definition of CE (Barreiro-Gen & Lozano, 2020; Lozano-Lunar et al., 2020; Salesa et al., 2022). The Ellen Macarthur Foundation (2020) defined CE as: "A systems solution framework that tackles global challenges like climate change, biodiversity loss, waste, and pollution", highlighting that CE basis is the waste and pollution suppression, nature regeneration and the circulation of products and materials. The European Union (2020) highlights that "CE is a system where the value of products and materials is retained for as long as possible through minimising waste and resource use and

reusing products when they reach their end of life, which can bring economic benefits and contribute to innovation, growth, and job creation".

All those definitions have some main pillars in common and can be summarised in that CE looks for the maximisation of the economic results by means of the optimisation of used materials (D'Amato et al., 2017, 2019; Mayer et al., 2019) and the improvement of resource efficiency (Iacovidou et al., 2019; Luciano et al., 2020) through larger—or even new—lives given to materials (Esposito et al., 2018; Linder & Williander, 2017; Witjes, 2016). In this way, CE contributes to sustainable development through its main pillars, which include reducing the number of materials used (Konietzko, Baldassarre, et al., 2020; Lozano, 2020), creating new designs (Baldassarre et al., 2019;

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Martinez Leal et al., 2020) that are more eco-friendly (Javier Cobo-Ceacero et al., 2019), developing products with newer materials (Blomsma & Tennant, 2020; Pearlmutter et al., 2020), and improving and enlarging life cycles.

The CE is widely spread in terms of legislation in Europe and China, but its adoption is still relatively low (Kimita et al., 2021; Rattalino, 2018). Although many companies claim that their business models are circular, there are no precise records of what practices companies are adopting to become circular (Cramer, 2020; Pieroni et al., 2020). This issue lies in the fact that there are still no indicators or elements that facilitate the measurement of the effectiveness of circularity, nor lists of best practices that allow measuring the level of circularity of a company (Korhonen, Nuur, et al., 2018; Saleisa et al., 2022). Furthermore, the CE proposes a production and management model for the manufacturing sector, but even today, there is not a great development of this model for the service industry (Blomsma & Brennan, 2017; Korhonen, Honkasalo, & Seppälä, 2018; Y. Liu & Bai, 2014; Molina-Moreno et al., 2017).

One of the industries that have traditionally and world-widely had the most sustainability activity within the service industry is the airline industry. Airlines emerged in the second half of the 20th century as a new means of transport for people and goods (Turkina et al., 2016). This sector has undergone important changes over time, and today it is the basis of many industries (Cobeña et al., 2019; Migdadi, 2018) due to the possibility of moving people and goods between countries in a minimum time. The high development of the industry is bringing to light some problems in terms of direct and indirect negative impacts of its activity, such as the significant increase in noise that exceeds the sound barrier (European Union, 2009; Mahashabde et al., 2011), or the changes in the land and soil that affect biodiversity, and which are nowadays inevitable due technical limitations of aircraft (Turkina et al., 2016). Raw materials such as kerosene, titanium and halon are also especially harmful to the environment (DeTienne & Koberg, 2002; Mahashabde et al., 2011).

The aircraft manufacturing industry has implemented circular models in aircraft production since the mid-1970s. New aircraft models have been drastically remodelled to incorporate eco-design features that reduce the raw material employed and the total waste generated. Aircraft production is one of the industries with a higher circularity level in its production chain (ICAO, 2020; International Civil Aviation Organization, ICAO, 2014).

Despite the fact that there is no standardised circularity model in the service industry, CE seeks cleaner production and better management of resources (Esposito et al., 2018; Ghisellini et al., 2016; Pishchulov et al., 2018), so many different streams of knowledge are currently trying to develop, adopt, and implement CE principles in the service industry. In this regard, it can be observed that the 3R and the Zero-Waste initiatives, adopting more efficient materials, and reducing used raw materials are currently expanding across airlines. In this context, a research question arises related to identifying the specific practices that companies are incorporating into their daily activities to support CE adoption through improving their waste management systems.

Therefore, this study seeks to identify a series of common practices related to circularity to create a framework that allows identifying the implementation of this new economic system within companies in the airline industry and to serve as a reference for other service industries. This study uses the CSR reports collecting information about the practices airlines adopt to incorporate a circular economy and, at the same time, proposes a framework to identify the circular practices of individual companies from the perspective of waste management. The framework is developed based on the environmental performance assessment tool for the airline industry proposed by Migdadi (2018) and (Alkhatib & Migdadi, 2020; Migdadi, 2018), which has been conveniently adapted. The gathered information is used to answer the following research questions. RQ1: What are the CE practices that airlines are adopting to improve their waste management systems and perform better from an environmental perspective? RQ2: Are airlines following a specific set of actions to implement CE to set new waste and material management strategies?

The present study is structured as follows: After this introduction, Section 2 provides a theoretical background, context, and general description of CE. Section 3 explains the research method. Sections 4 and 5 present the main results and the discussion, and finally, Section 6 presents the main conclusions.

2 | THEORETICAL BACKGROUND

2.1 | Circular economy as a business model

Linear economy (LE) is not sustainable in the long term. Production processes still require large amounts of raw material to manufacture goods, and the availability of natural resources is limited. Alternative production models have emerged, and researchers and practitioners are working together to advance new economic models to reduce the use of raw materials and produced waste and to enlarge product life cycles. CE can reduce waste and save remarkable amounts of raw materials (Foundation, 2013; Zhong & Pearce, 2018). Many practitioners defend that CE principles are focused on leaving behind any possible harmful behaviour against the environment (Lieder et al., 2017; Murray et al., 2017). CE is expected to improve the resilience of nature and repair any previous damage due to its main principles, which include nature protection and materials recovery (D'Amato et al., 2019; Harris et al., 2021). There are several theories and definitions of CE. Nonetheless, most practitioners agree to define it as a new approach in search of cleaner and more ecological products based on eco-design and focused on reducing waste and pollutants (Korhonen, Nuur, et al., 2018).

Some countries have already begun to incorporate the closed-loop system (CLS) as a new production model, leading to a greener alternative to the existing one. The main objective of CLS is to reuse material waste generated during the production process and, at the same time to use recycled products to create new ones (Harris et al., 2021; Lindgreen et al., 2020; Tavares et al., 2020; Walzberg et al., 2021).

Nonetheless, many limitations hinder the effective adoption of CE (Linder & Williander, 2017; C. Liu & Côté, 2017). Several studies show that public and institutional support is still low (Bolger & Doyon, 2019; Clark, 2018) and that no specific industry has adopted CLS as its main production model, mainly due to the technical and financial requirements (Linder & Williander, 2017). Besides, more research is still needed to make the CE model universal and to design a stream of knowledge that takes CE actions from the manufacturing industry to the service industry (Linder & Williander, 2017; Y. Liu & Bai, 2014).

CE models in the service industry are currently limited to adaptations of the manufacturing models as the official from Ellen MacArthur Foundation (2020). For this reason, there are no good practice guidelines (Halstenberg et al., 2019; Saleasa et al., 2022) nor standard models (Korhonen, Honkasalo, & Seppälä, 2018; Millette et al., 2020; Siman et al., 2020) designed with the specificities of the service industry, and there is no set of tools or frameworks to identify or measure the adoption of CE (Millette et al., 2019; Siman et al., 2020). Despite the absence of a standard model, this paper contributes with the idea that it is possible to extract and identify parts of the CE model for manufacturing companies that can be extrapolated to the service industry based on the circular practices they promote. Following Konietzko et al. (2020) (see Figure 1), the contribution of business practices to CE could be understood from four different perspectives: Slowing the cycle (increasing the use), Closing the circle (using them several times), Regenerate (using cleaner products) and Narrowing the circle (use fewer materials)

2.2 | Airlines' sustainability and waste management

The increase in flights brings to light some problems in terms of direct and indirect negative impacts. These are being considered by airlines,

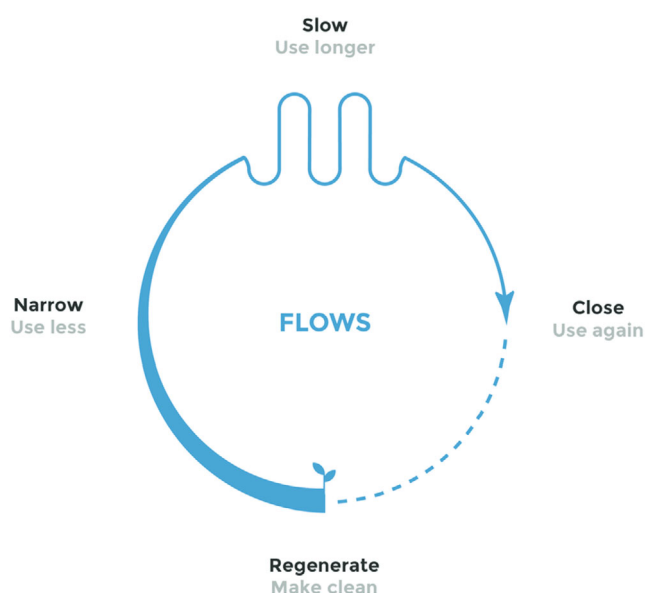


FIGURE 1 Circular economy flows. Source: Konietzko et al. (2020) [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/doi/10.1002/csr.2365)]

which have begun implementing CE principles to improve their performance on the triple bottom line and sustainability. New aircraft production characteristics actively address or reduce some of the major problems. Nonetheless, as the air transport industry involves most of the countries in the world, most aspects related to environmental issues are strictly regulated, and there is scarce flexibility to incorporate innovations in how some of the negative aspects are managed. Whereas regular industries depend on technology and other technical improvements, airline industry growth also depends on countries' regulations (Kleymann & Seristö, 2020).

In terms of contribution to sustainable development, two main approaches are being adopted by airlines. On the one side, companies are promoting changes in the power energy supply. Those changes are based on renewable resources (Douglas & Tan, 2017; Kleymann & Seristö, 2020), like sustainable fuels based on biomass. These new fuels present the advantage that they are CO₂ neutral when compared to alternatives based on fossil energies (Cobeña et al., 2019).

On the other side, companies are increasing their awareness of material management and waste produced during flights. As a result of air transportation services, waste is generated by passengers and cabin crew. Several researchers (Cobeña et al., 2019; Kleymann & Seristö, 2020) claim that in-cabin waste is the most common waste for airlines worldwide, and it is 70% generated by passengers (Abdullah et al., 2016).

Some types of waste are directly managed by airlines, such as packaging, plastics, papers and food waste, while other kinds of waste are managed by airports or maintenance companies and concretely originated from the regular use of aircraft (Abdullah et al., 2016). Airlines do not usually do the maintenance tasks of aircraft by themselves. Instead, they contract aerospace producers or specific companies to manage aircraft maintenance. Therefore, after discarding waste linked to aircraft degradation and maintenance, which are generally out of their control, two kinds of waste are directly linked to airlines activity (ICAO, 2014), inedible waste and edible waste (IATA, 2019).

Inedible waste comprises many different everyday items, including newspapers, paper towels, plastic bottles, amenity kits and plastic wrapping from blankets, pillows, and headsets. As the passengers and cabin crew also use washroom bins and hygienic stuff, this type of waste is considered in-cabin waste. Inedible waste is widespread on flights, and as many studies suggest, its sustainable management should be based on the use of improved management systems and the introduction of new materials to make more environmentally friendly products (Abdullah et al., 2016; ICAO, 2020).

Edible waste refers to wastes that result from the feeding of passengers and cabin crew. A growing number of associations and governments (Garnett & Wilkes, 2014; Papargyropoulou et al., 2014) identify food waste as a priority issue due to the high level of pollution that it brings (You et al., 2020). Every airline offers its customers an on-demand catering service to provide them with food and beverages during the flight. This catering service requires airlines to store several references to have a variety of products to offer to passengers. In this way, passengers have an extensive list of products to



choose from but require flights to have larger stocks than needed. Furthermore, these catering services generate large amounts of waste, such as food and beverage packaging and cutlery (usually made of plastic).

All in-cabin waste is subject to national sanitary waste controls, which, in most countries, require the burning of all edible waste from international flights (Kleymann & Seristö, 2020; You et al., 2020). Due to this regulation, the best way to improve the efficiency of edible products is based on predicting the approximate amount of food that will be necessary to satisfy the needs of each passenger and reduce overstocking (International Air Transport Association, 2021). Airlines have started to develop new prediction systems based on artificial intelligence and passengers' behaviour to estimate the food stock needed to match passengers' demands. The meal booking systems would allow airlines to have accurate information on the number of meals needed and significantly reduce waste.

In this context, and taking into account that there is no commonly accepted model for CE in the service industry, this paper studies the adoption of CE practices by airlines. More concretely, this paper focuses on the materials and waste management practices due to a twofold motivation. On the one hand, due to the important impacts, they represent within the industry (Amankwah-Amoah, 2020). On the other hand, because of the possibility that airlines still have to directly manage them, despite the restrictive regulations (Castiglioni et al., 2018; Douglas & Tan, 2017).

3 | RESEARCH METHOD

3.1 | Sample

This study focuses on CSR reports for the years 2019 and 2020 (before the COVID pandemic crisis) of airlines operating international flights. To gather a representative sample, we have used lists of airlines disclosed in reports of international aviation organisations (IATA, 2019; ICAO, 2020). The initial set was selected with the intention of getting a sample of airlines with a presence in the most important airports worldwide. By selecting airlines operating in specific airports, we choose airlines subject to similar legislative restrictions as they run their activity under the same strict legislation. In addition, these airports have been making important efforts to be more sustainable and incorporate new sustainable business models to reduce pollutant activities. Specifically, selected companies operating in the United States of America (JFK Airport), Spain (Adolfo Suarez Madrid Barajas Airport), London (Gatwick Airport), China (Beijing Capital International Airport), Netherlands (Schiphol Airport) and Dubai (Garhould International Airport). Only airlines using all these airports were considered. Airlines selected in this way are expected to show high sustainability orientation with a significant commitment to the incorporation of alternative business models, as CE is.

The initial selection was composed of 106 airline groups. As the groups can be heterogeneous, we assume that the company's main activity was air transport when it represented the biggest income

data. Then, it was verified whether selected companies published a CSR report and whether they mentioned waste management, and they were discarded otherwise.

CSR reports have been used to identify those activities related to waste management that could be associated with CE practices. As far as there not exist specific toolkits to measure and disclose CE practices, this paper considers CSR reports a good source of information for waste management practices. Concretely, we analyse the CSR reports for the last two years at the moment of performing the research, that is, 2019 and 2020. Note that the information disclosed in them is referred to the years 2018 and 2019 as the information is published after the end of the fiscal year.

CSR reports were collected from the companies' websites or from the head company website in the case of groups. In the cases where there was a specific report for the head and the dependent company, both documents were analysed. In these documents, it was analysed any information that could serve to identify CE practices related to waste management systems. The analysis was carried out based on a search for practices and looking for some specific keywords in the document, such as "circularity", "circular economy", "waste", "waste management", and "recycling", and words containing its main root. Furthermore, it is remarkable that whenever there were supplementary documents related to CE practices linked or referred to in the CSR report, the information was also included in the study, following a snowballing process (incorporating every document with CE information). Figure 2 summarises the sampling process.

The final sample includes 64 groups from all over the world with a presence in 43 different countries. As shown in Figure 3, the highest concentration of airlines is located in Asia and European countries, while the representation of African companies is shallow (a relevant number of African companies was removed due to the absence of CSR reports). Concretely, there are 33 European companies, 18 Asian, 10 American (both North and South America), 2 from Oceania and 1 from Africa.

3.2 | Methodology model

This paper uses a method based on the analysis of CE practices adopted by airlines to improve their waste and material management. The method is based on the hierarchy defined by (Alkhatib & Migdadi, 2020; Migdadi, 2018), and it is focused on the analysis and classification of specific sustainable practices. More concretely, material and waste management practices are addressed.

The identification of practices was performed as follows. A set of keywords was searched in the reports and linked documents in order to identify any reference to practices that could be related to CE principles in the field of research, and special attention was given to those related to waste management. Used words included: "circular", "circularity", "circular economy", "waste", and "waste management". To identify and classify the practices, we followed a specific hierarchy defined following the criteria of the three authors and that facilitates the classification of the practices identified.

FIGURE 2 Sample gathering and refining.

Source: Self-made

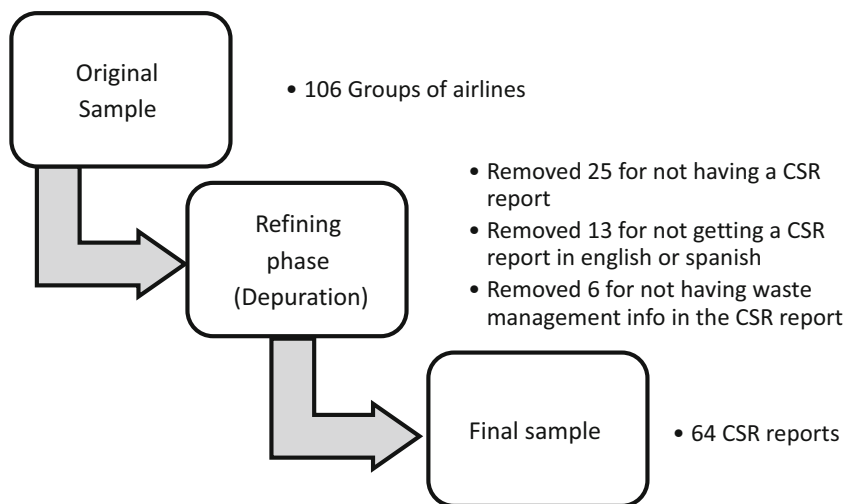
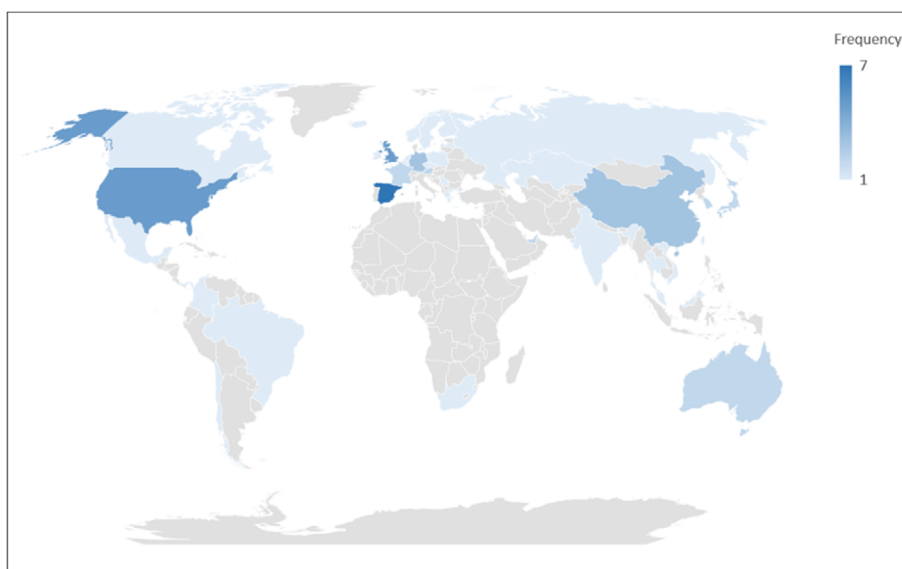


FIGURE 3 Countries of the Sample.

Source: Self-made [Colour figure can be viewed at wileyonlinelibrary.com]



The proposed framework is focused on analysing the materials management, recycling processes, and adopting materials based on a practical and eco-efficient design. The original model (see Annex 1 in Data S1) (Alkhatib & Migdadi, 2020) is extracted from a method focused on measuring sustainable and green airline issues. As not every sustainable issue is linked to CE, the proposed framework ignores every initiative not directly related to CE and waste management. Therefore, the framework is only focused on analysing those activities related to waste management, the efficient and innovative use of materials, and the inclusion of new materials and products. Furthermore, the conducted analysis also focuses on how some existing elements of the cabin are being transformed to match CE principles. Finally, due to the importance of edible waste, several aspects were added to the framework linked to food waste in the industry. These initiatives are focused on the practices recommended by international associations such as IATA or ICAO to improve edibles management. Concretely, the initiatives added are the availability of booking systems to predict the number of meals needed and the composition of

edibles packaging. All these activities are important CE initiatives explicitly linked to the airlines industry (ICAO, 2014; Markatos & Pantelakis, 2022)

The original hierarchy is composed of a total number of 58 identifiable activities classified into seven global categories. As these actions are not always directly linked to improvements, changes or innovations specific to CE, the present study proposes a substantial modification in the proposed hierarchy in order to focus only on the CE-related actions. The resultant hierarchy that allows defining the final framework is composed of global categories and 23 general initiatives, which have been used to classify the practices identified in the CSR reports and serve as a reference to propose the framework. The used hierarchy is defined as follows:

Initiatives hierarchy:

- C1. Onboard and ground waste recycling
 - I1. Recycling tracking system
 - I2. Internal Auditing in recycling



- I3. In-cabin Waste management system
- I4. In-cabin material recycling
- I5. Recycling paper
- I6. Recycling plastic
- I7. Recycling cans
- C2. Onboard and ground waste upcycling (Materials recovery and production improvements)
 - I8. Outdated uniforms to manufacture amenity bags and kits
 - I9. Uniforms reused to create furniture blankets
 - I10. New eco-friendly materials
 - I11. Plans and actions to remove plastics
 - I12. New products design (Repairability)
 - I13. New products design (Recyclability/Reusable)
- C3. Reducing the use of paper
 - I14. Using electronic airway bills
 - I15. Using electronic boarding passes
 - I16. Providing cabin crew with iPads/tablets instead of magazines/newspapers and other reading articles
- C4. Upcycling industrial waste
 - I17. Burning waste to recover energy
- C5. Processing hazardous waste
 - I18. Recycling hazardous waste
 - I19. Tracking systems to track hazardous material early
- C6. Upcycling hazardous waste
 - I20. Burning hazardous waste to recover energy
- C7. Food Waste Management
 - I21. Food stock prediction or booking system
 - I22. Food waste management
 - I23. Food eco-friendly packaging.

TABLE 1 Initiatives are identified by the percentage of adoption in airlines.

Initiative	% Airlines
Recycling plastic	96.9%
Recycling paper	92.2%
Recycling tracking system	76.6%
Recycling cans	70.3%
New eco-friendly materials	68.8%
Plans to remove plastics	64.1%
In-cabin waste	62.5%
Internal auditing in recycling	59.4%
New products design—repairability	50.0%
Burning hazardous waste to recover energy	48.4%
In-cabin material recycling	46.9%
Using electronic airway bills	43.8%
Providing cabin crew with iPads/tablets, no paper	37.5%
New products design—recyclability	32.8%
Burning waste to recover energy	32.8%
Food stock prediction (booking system)	32.8%
Using electronic boarding passes	28.1%
Food waste management	28.1%
Recycling hazardous waste	26.6%
Food eco-friendly packaging	25.0%
Tracking systems to track hazardous material early	21.9%
Uniforms to manufacture amenities	18.8%
Uniforms reused to create furniture blankets	10.9%

4 | RESULTS

4.1 | Initiatives assessed and highlighted practices

Table 1 shows the level of adoption that airlines present for the diverse initiatives in the framework. In this table, a company is considered to adopt an initiative when at least one practice has been identified in the analysed reports, and it is classified as contributing to the initiative.

As it can be observed, airlines are mainly focusing on initiatives including recycling plastic (96.9%), paper (92.2%) and cans (70.3%), promoting an internal recycling tracking system to track how waste is being managed (76.6%), and incorporating new eco-friendly materials to replace those “hard-to-recycle” elements (68.8%). On the opposite side, few airlines are focusing on developing systems to track how hazardous wastes are managed (21.9%), and outdated uniforms are not getting new uses. Few airlines are using old uniforms for manufacturing parts of the amenities (18.8%) or creating furniture blankets (10.9%), among other uses.

By global categories, the following figures show the most common practices adopted by airlines, which also reveal the initiatives that are mainly addressed to move towards circularity.

In relation to Onboard and ground waste recycling, Figure 4 shows companies are developing systems to track waste management (38 airlines) and promoting the 3Rs (27). The other notable practice is the management and recycling of the waste in the cabin; various measures are being adopted, such as classifying waste in the cabin while the flight is still underway (29) and teaching the cabin crew to manage this waste properly (21). Finally, a highlightable number of companies carry out specific activities to promote paper and plastic recycling. Among others, we find the recycling of company magazines (22), the collection of PET waste (31) and the implementation of new recycling methods to promote the recovery of plastic (27).

Figure 5 shows the main practices taken by companies to upcycle waste (C2). First, focusing on using ecological materials, several airlines declare to use of biodegradable materials to replace those that are not easily recyclable (34) and the introduction of bamboo and other plant materials to produce some of the daily used elements. Second, there is a high movement focused on eliminating the use of plastics on flights. The main general plans are to reduce the amount of plastic used (39). However, some specific practices include removing single-use plastics (39), removing plastic packaging from products sold in flight (22), and replacing plastic cutlery elements with others made with different materials. Thirdly, the new design and repairability of products stand out, where it is important to highlight the removable

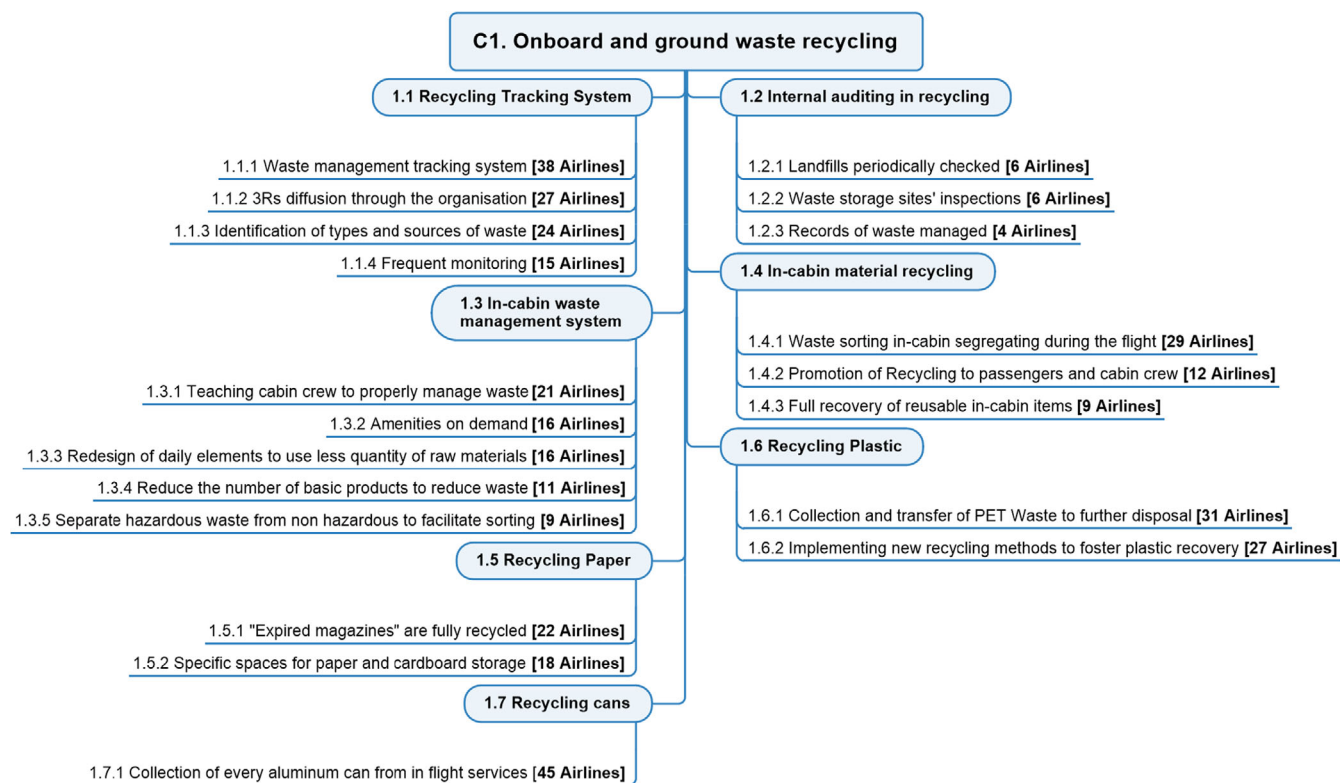


FIGURE 4 Onboard and ground waste recycling—practices [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/doi/10.1002/csr.2365)]

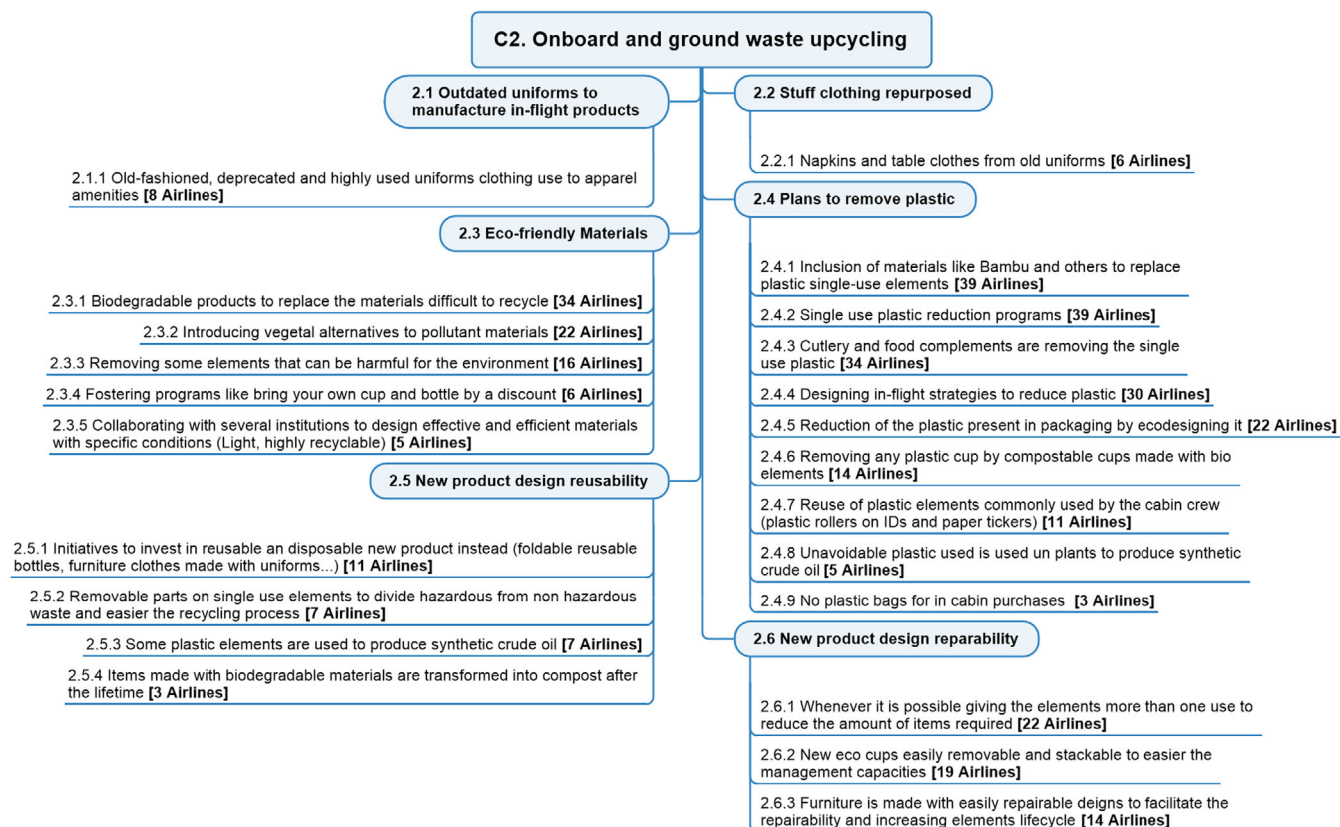


FIGURE 5 Onboard and ground waste upcycling—practices [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/doi/10.1002/csr.2365)]

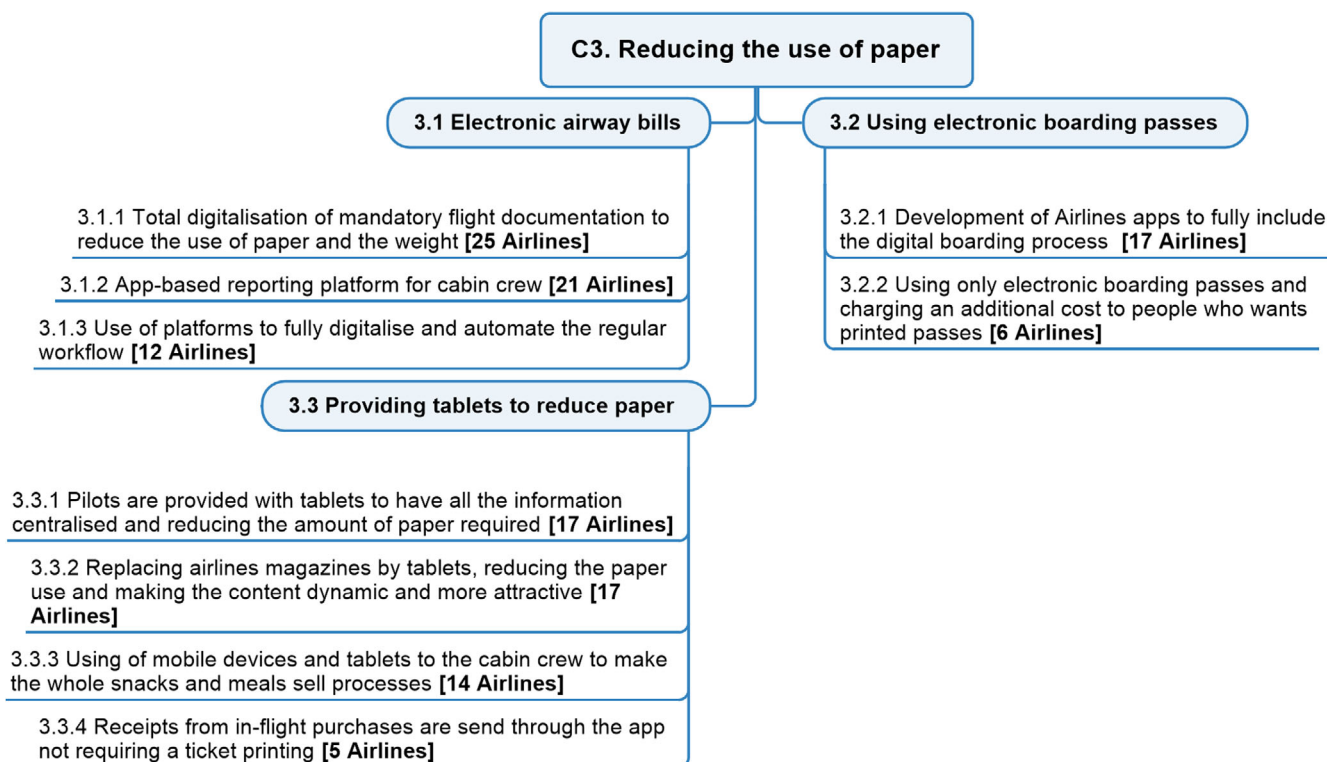


FIGURE 6 Reducing the use of paper—practices [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/doi/10.1002/csr.2365)]

and stackable eco-cups (19), increasing the lifetime of products (22) and easily repairable and replaceable furniture (14).

In relation to reducing paper use, Figure 6 shows that airlines are implementing nine main practices, which contribute to the three different initiatives within the category. There are some quite common practices such as the use of apps to digitalise the cabin crew work (21), the digitalisation of mandatory documents (25), the development of airline apps to fully digitalise boarding passes, and the use of tablets to remove completely the physical magazines and mandatory papers used by pilots (17).

Figure 7 shows the main practices taken by companies to recycle and upcycle hazardous waste. There are not so many specific practices to manage hazardous waste, but it is significant how several companies send all hazardous waste to specialised handlers (16). Moreover, many companies agree to burn waste that cannot be quickly processed due to its composition or potential negative impact (30).

Finally, in relation to the management of food waste, Figure 8 summarises the main practices adopted by airlines. A specific movement focused on reducing the amount of food transported on each flight and reducing the negative impact of its packaging. On the one hand, the incorporation of meal booking systems (16) reduces the amount of food that needs to be transported. On the other hand, to minimise food-related waste, some initiatives have emerged, such as incorporating reusable dishes and cutlery made with biomaterials (19) and napkins and amenities made with recycled materials (12) only given to passengers when they demand them.

4.2 | Practices implications in closing the loop

The identification and classification of practices adopted by airlines make it also possible to extend the analysis and to define which of the perspectives of CE are mainly present. As each practice is being adopted by different companies, it is also important to note what is the actual contribution of the practice in terms of “closing” the loop. Table 2 indicates the related dimensions of CE that are improved with the adoption of the diverse practices identified in the airline industry and summarises the percentage of practices that are related to each dimension.

Table 2 also evidences there are no important differences in the dimensions of CE that are promoted by the diverse practices adopted by airlines. In fact, 26 out of 68 practices promote two or more dimensions, which can be expected as some of the initiatives undertaken are based on sharing the principles of CE from a perspective of teaching and sharing the knowledge.

4.3 | Interdependence among practices

The Chi-square test (Annex 2 in Data S1) shows that some practices are interlinked and tend to be adopted together. Nevertheless, no such significant relation nor companies follow a specific concrete path. Therefore, the actions promoted by companies seem not to follow a set of rules or a concrete relation but just a fuzzy standard, with some aspects in common but not an actual set of things.

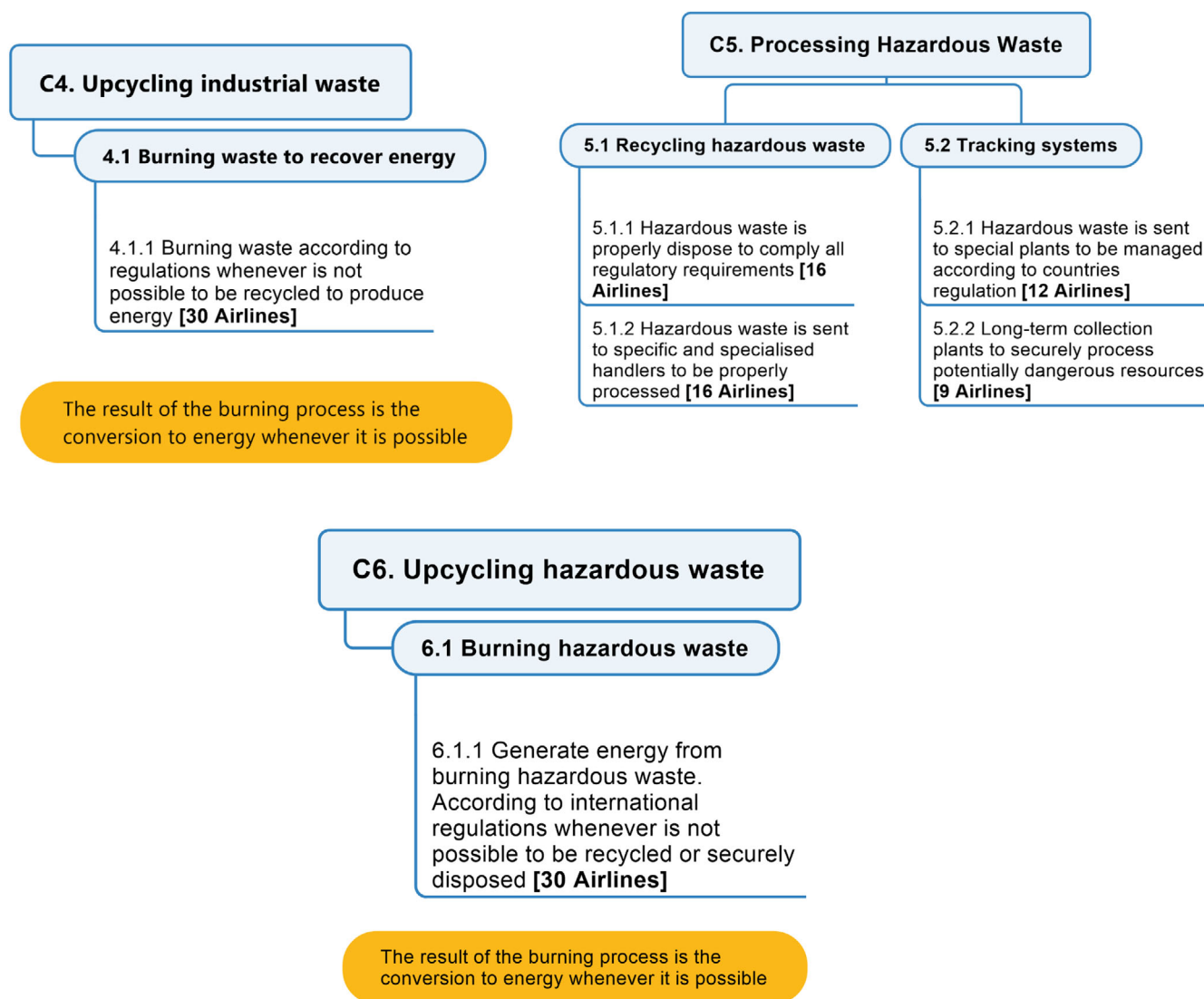


FIGURE 7 Recycling and upcycling hazardous waste—practices [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/doi/10.1002/csr.2365)]

In relation to the most frequent sets of practices, the association analysis performed with the apriori algorithm identifies 4 groups of

5 practices that are presented in 17 of the airlines in the sample. Those groups are:

Waste management tracking system	Biodegradable prods to replace the materials difficult to recycle	Introduction of vegetal alternative to pollutant materials	Cutlery and food complements are not single-use plastics	Designing in flight strategies to reduce plastics
Waste management tracking system	Single use plastic reduction programs	Introduction of vegetal alternative to pollutant materials	Cutlery and food complements are not single-use plastics	Designing in flight strategies to reduce plastics
Collection and transfer of PET waste to further disposal	Single use plastic reduction programs	Introduction of vegetal alternative to pollutant materials	Cutlery and food complements are not single-use plastics	Designing in flight strategies to reduce plastics
Biodegradable prods to replace the materials difficult to recycle	Single use plastic reduction programs	Introduction of vegetal alternative to pollutant materials	Cutlery and food complements are not single-use plastics	Designing in flight strategies to reduce plastics

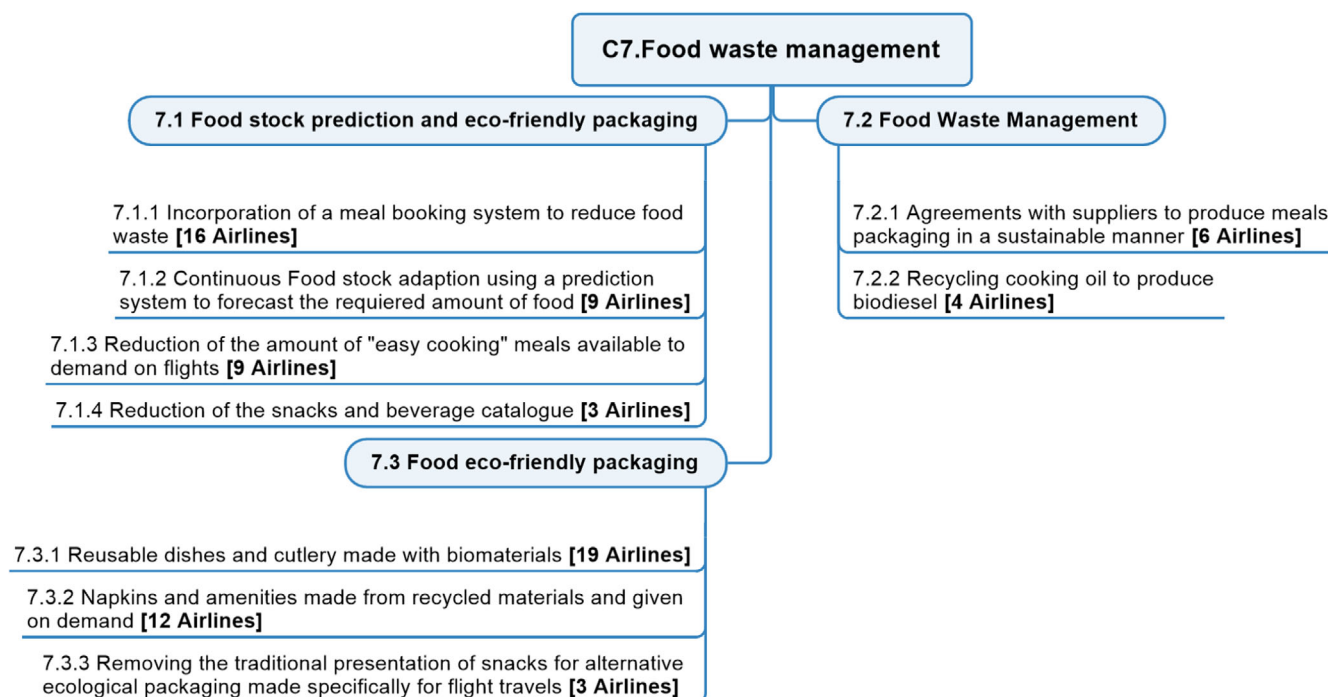


FIGURE 8 Food waste management—Categories, initiatives and practices [Colour figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com/doi/10.1002/csr.2365)]

Among them, we identify 2 groups of 5 practices that are presented in 30 airlines:

Single use plastic reduction programs	Introduction of vegetal alternative to pollutant materials	Cutlery and food complements are not single-use plastics
Introduction of vegetal alternative to pollutant materials	Cutlery and food complements are not single-use plastics	Designing in flight strategies to reduce plastics

5 | DISCUSSION

5.1 | Headquarters' country

A total of 64 airlines disclose information on CSR activities. The degree of disclosure changes among them, which may be caused by facts like the level of support of public CE initiatives.

The country of origin can be one of the diverse considerations. On the one hand, China and Europe have been developing CE since 2009 and 2012, respectively, introducing various laws that incentive cleaner production initiatives and closed-loop production systems. Furthermore, the EU has strengthened the transition to CE by disseminating a more developed set of tools for promoting CE and bio-economy promotion through the “Circular Economy Action Plan”,

which is aimed at rethinking resource efficiency and material waste. Focusing on Asian companies, it is seen they still lack a wide CE adoption since the number of companies that disclose CE information was limited. Although China adopted the “Circular Economic Promotion Laws” in January 2009 (Friant et al., 2020), results indicate that it has no significant effects on the companies (Lieder et al., 2017).

On the other hand, the European Union case is highly remarkable, where countries began to adopt CE later than China, but in some cases with a higher level of commitment. The Netherlands is making a great effort to make its society, in general, much more sustainable (European Union, 2020). The country is making great strides in CE across all industries, including the manufacturing and service industries. The case of Amsterdam Schiphol Airport is particularly noteworthy because of the several circular initiatives that are being adopted, which are making the airport become the most sustainable airport in the world despite the high number of daily travellers (International Air Transport Association, 2021; Kılış & Kılış, 2017). Among those initiatives, it is worth mentioning: (1) Achieving the objective of becoming a zero-waste airport, where raw material and each component and product is reused or recycled as much as current technology allows; (2) Eco-design of almost all airport components except those elements that must follow a specific composition due to the technical or sanitary specifications; (3) Application of the 10Rs approach to managing all residual waste; and (4) Reinforce the inclusion of strategic resource management, especially to manage flight waste and to allow the recycling of waste that was previously incinerated, as it is still done in many airports around the globe.

Several of the practices adopted by companies seem to be inspired by the ones indicated by International Air Transport

**TABLE 2** A practice framework proposal

	Practice	Slow	Close	Regenerate	Narrow
Onboard and ground waste recycling	1.1.1		×	×	
	1.1.2	×	×	×	×
	1.1.3		×		×
	1.1.4		×		×
	1.2.1		×		×
	1.2.2		×		
	1.2.3	×	×		
	1.3.1		×		
	1.3.2	×	×		
	1.3.3				×
	1.3.4			×	
	1.3.5	×	×	×	×
	1.4.1				×
	1.4.2	×		×	
	1.4.3			×	
	1.5.1	×	×		
	1.5.2		×		
	1.6.1		×		
	1.6.2			×	×
	1.7.1		×		
Onboard and ground waste upcycling	2.1.1	×	×		
	2.2.1	×	×		
	2.3.1			×	
	2.3.2			×	
	2.3.3			×	×
	2.3.4	×			×
	2.3.5	×		×	×
	2.4.1				×
	2.4.2			×	
	2.4.3			×	
	2.4.4				×
	2.4.5				×
	2.4.6				×
	2.4.7				×
	2.4.8		×	×	
	2.4.9				X
	2.5.1	×	×		
	2.5.2			×	
	2.5.3	×	×		
	2.5.4	×	×		
	2.6.1	×		×	
	2.6.2		×		
	2.6.3		×		
Reducing the use of paper	3.1.1				×
	3.1.2				×
	3.1.3				×

(Continues)

TABLE 2 (Continued)

	Practice	Slow	Close	Regenerate	Narrow
	3.2.1				×
	3.2.2				×
	3.3.1	×			×
	3.3.2				×
	3.3.3	×			×
	3.3.4			×	
Recycling and upcycling hazardous	4.1.1			×	
	5.1.1			×	
	5.1.2			×	
	5.2.1			×	
	5.2.2				
	6.1.1			×	
Food waste management	7.1.1			×	
	7.1.2				×
	7.1.3			×	
	7.1.4				×
	7.2.1				×
	7.2.2	×		×	×
	7.3.1		×		
	7.3.2	×			×
	7.3.3			×	×
	TOTAL	18%	24%	26%	32%

Association (2021) that the different airports are applying. In this regard, it could be concluded that one of the options to increase CE adoption is the adaption of practices undertaken by airports, which are lately transmitted to airlines.

5.2 | Circular initiatives

When adopting CE principles in waste management, the most frequent initiatives for airlines are aligned with recycling plastic and paper and obtaining a specific recycling tracking system. Those initiatives require big changes in the organisation of flights. Due to the diversity of origins of the flights, traditionally, recycling is not allowed for public health actions. However, legislation is slowly but increasingly moving towards a new perspective in which some types of waste are beginning to be processed to reduce the waste generated. Among those materials, plastic items, paper and cans are remarkable. At the same time, most companies actively pursuing CE practices are phasing out plastics and transitioning to more environmentally friendly materials. In this way, the companies grant that if the packaging cannot be recycled due to strict regulations, contamination will be minimal compared to plastic (Markatos & Pantelakis, 2022).

However, some issues remain unchanged, and this is the case of food waste, not only organic elements but also their packaging, for which all waste must be incinerated due to public health

requirements. Additionally, even though some initiatives are starting to reuse organic waste, this effort has still some relevant controversy, as the health and safety regulations in some countries are highly strict. Further development of these initiatives to make the feeding systems more efficient may require governments to soften the laws.

It is necessary to talk about food from another perspective and not only manage its waste. As shown above, the sale of food and beverage is one of the priority activities on board. Several airlines are beginning to develop meal booking systems to reduce food waste and schedule the number of edibles required for each flight. These systems allow airlines to estimate the number of resources required for each flight. Travellers can order the foods they like and avoid any allergic reaction because the components of each dish are disclosed on the company's apps and website. In this way, the amount of waste will be reduced from the origin, transitioning to a cleaner system

5.3 | Waste typologies

According to the results, inedible waste is being reduced by companies by incorporating new and more eco-efficient materials, which allows satisfying customer needs while reducing the negative environmental impacts. Besides, companies are actively reducing the amount of material required to produce cabin furniture or passenger



accommodation elements and replacing the composition of amenities bags. Contrarily to these practices, several airlines are focusing their efforts on recycling processes. With this approach, companies do not change the production or composition of items but instead try to maximise the number of recycled items. While recycling is an excellent approach to recovering materials, CE models are also focused on materials optimisation to minimise the use of raw materials. Companies mainly focus on approaches related to waste management instead of waste reduction (as CE prioritise). Therefore, from the side of inedible waste management, CE principles could be more widely adopted.

The other predominant type of waste is food waste, which has great difficulty in managing the surplus. As the food is organic waste, several countries have established strict rules aimed at protecting public health or the national flora and fauna. Since the restrictions are different from country to country and often require further transfer to processing and incineration, food waste is not easy to manage. For these reasons, companies have begun to design alternatives to reduce food waste and food packaging waste from their origin. For example, by using food booking systems, passengers can reserve complete menus or some specific snacks at a lower price (IATA, 2021), and companies have started to design product packaging with alternative ecologic materials and organic elements. Within this kind of initiative, some airlines have reduced this type of waste, even though some of them are still being tested to increase their efficiency and efficacy (Aydas et al., 2021; Bender et al., 2022; Nakornkao & Mongkalig, 2022)

5.4 | Service industry limitations

Some airline groups are based in countries which still do not include the CE due to many facts, such as the lack of a concrete and specific model applicable to all companies and the high level of investment required to complete the production system's entire transformation. This reduced impact could also be explained because of the existing CE regulation that has traditionally focused on the manufacturing industry instead of being universally designed, leaving aside the service industry.

Practitioners and scholars have devoted great efforts to the design of alternative production models and strategies to reduce the impact of production processes in the manufacturing industry. If we review the aircraft's production process, several companies design aircrafts focusing on a pure comprehensive eco-design, and almost every part of an aircraft is designed to be easily repairable or replaced. However, there are no specific models to adopt circular economy principles in the service industry, which limits that companies adopt them. Also, the transition to a circular model requires many resources and capital, so it is necessary to design the transition carefully and evaluate the overall performance.

Some studies have shown that the adoption of CE increases the efficiency of resource optimisation and improves sustainability performance. For this reason, some circular models are emerging that link the transition from the traditional manufacturing industry to the

service industry. More specifically, researchers are measuring how rejecting those suppliers that do not include CE principles in designing and manufacturing their products could easily increase the environmental performance of airlines by reducing waste and fostering recycling activities (Aydas et al., 2021). Some airlines have started to choose suppliers according to their environmental strategies. Specifically, several companies only deal with suppliers that produce products such as meal packaging, cutlery, and many other amenities with sustainable practices. In addition, those products and amenities should be made with recycled materials, when possible, and should be easily recyclable. The companies that have adopted these requirements have been integrating CE in other aspects, and the results published by airlines show they are reducing the amount of trash. Besides, concerning meal packaging and restrictive regulations, signing agreements with suppliers to produce environmentally friendly packaging could be the only solution to process those materials properly.

6 | CONCLUSIONS

Industries worldwide are fostering the inclusion of CE and CLS in their production systems due to the limitations of the Linear Economy. Airlines and aerial transport have been adopting sustainable measures for decades to reduce the negative impacts on the environment. Several of these impacts could be addressed by adopting approaches that drive airlines' actions through a greener and cleaner perspective. This paper aims to create a framework that collects and organises those practices adopted by the airline industry to improve their sustainability performance and transition to a circular model. To this end, a qualitative analysis of the CSR reports of a sample of companies in the industry has been performed in order to identify circular economy practices related to waste management and to classify the following a specific hierarchy.

Results show airlines are embracing CE and fostering their efforts in initiatives like recycling plastic, paper, and cans, promoting an internal recycling tracking system to track how waste is being managed, and incorporating new eco-friendly materials to replace those "hard-to-recycle" elements. On the other side, airlines are also enhancing and promoting the proper use of materials and implementing new recycling methods to encourage the recovery of plastic and using biodegradable materials to replace those elements that are not easily recyclable, even fully removing the single-use plastics.

Despite the practices undertaken by companies, there are still options for improvement in terms of practices to transition to CE. Nevertheless, it is important to consider the limitations that CE models have in the service industry as the lack of an official model to apply to incorporate CE. Furthermore, the technical and economic resources required to develop CE hinder a proper transition for airlines to embrace CE.

Definitively, airlines are actively developing easy actions such as recycling every kind of in-cabin waste and adopting some specific actions like incorporating biodegradable materials and incorporating advanced and sustainable manners to offer catering services on board,



reducing the waste generated. In fact, some of the main practices adopted are focused on reducing the new materials use or reducing the amount of raw and harmful materials, that is, practices that narrow and regenerate the circle of materials. However, the analysis discloses that practices are not significantly interrelated among them. In fact, in most cases, there is not a clear relationship between the practices adopted by the companies, which means that CE strategies designed by companies are not following a specific common path and that each airline is focusing their actions on the practices they consider more relevant or easier to adopt. For this reason, the framework proposed in this work may serve as a basis for further developments aimed at measuring the advancement of the CE practices in the companies in coming years and, at the same time, allows to compare the approaches that companies are adopting in their transition to CE.

The results of this study are limited due to some limitations. First, the framework has been developed using data extracted from a limited set of CSR reports and related documents since few airlines report specifically about circularity and circular economy. In the same way, some of the practices might not be directly linked to circularity on airlines as there are no specific guidelines nor key performance indicators to determine if a practice is CE attributable. Additionally, there is a limitation related to the scope and the contents covered by the analysis due to the fact that circularity information is still highly limited in the airline industry. Therefore, the present study allows to determine the actions companies are undertaking to incorporate CE, but it is still not possible to determine the actual impact. In the case of companies that are part of the same business group, we have taken the matrix airline data because, by general rule, there was not enough sustainability information in the dependent firms' reports. When an existing airline is merged or absorbed by a bigger airline, the final report discloses CSR combined information deprecating the individual one.

This paper may support forthcoming studies around CE in the services industries. Similar studies may be conducted in other services industries to advance in the formalisation of frameworks and standards. The set of best practices, jointly with the development of key performance indicators, may also serve as a base for the development of measures for CE performance measurement and impact assessment of best practices. At the same time, the application of the framework in a different sample and momentum could be translated into a more detailed sight of the whole airline CE actions and the advancement of CE in the industry

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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