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GREEN AIRPORT, CONCEPT AND GENERAL DEVELOPMENT FRAMEWORK

AEROPUERTO VERDE, CONCEPTO Y MARCO GENERAL DE DESARROLLO

AEROPORTO VERDE, CONCEITO E QUADRO GERAL DE DESENVOLVIMENTO

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RESUMEN

Los aeropuertos de todo el mundo están aumentando sus esfuerzos para reducir los impactos que generan en el medioambiente mediante la aplicación de sistemas de gestión ambiental. Esta línea de actuación de la industria aeroportuaria, que no lleva más de quince años, tiene el objetivo de transformar el aeropuerto en lo que se denomina 'aeropuerto verde'. Este se entiende como aquel aeropuerto que tanto su diseño como operación y administración se llevan a cabo de tal manera que su impacto ambiental es el mínimo posible, haciendo su gestión de carácter sostenible. Entonces, en el presente artículo se presenta un marco general de desarrollo del concepto, junto con un análisis de los procesos operativos de los aeropuertos que afectan negativamente al medio ambiente. A partir de lo anterior se sugieren políticas, estrategias y procesos de gestión que permitan minimizar o anular dichos efectos negativos en el entorno aeroportuario con el propósito de acercarlo hacia el concepto de 'aeropuerto verde'.

Palabras clave
aeropuerto verde, gestión ambiental de aeropuertos, aeropuertos sustentables

ABSTRACT

Airports around the world are increasing their efforts to reduce their environmental impacts by implementing environmental management systems. This line of action of the airport industry, which has been in place for no more than fifteen years, aims to transform the airport into what is called a "green airport." This is understood as an airport whose design, operation, and administration are carried out in such a way that its environmental impact is as low as possible, making its management sustainable. Therefore, this article presents a general framework for developing the concept, along with an analysis of airport operational processes that negatively affect the environment. Based on this, policies, strategies, and management processes are suggested that allow minimizing or canceling these adverse effects on the airport environment to bring it closer to the concept of a "green airport."

Keywords
green airport, environmental management of airports, sustainable airports

RESUMO

Os aeroportos de todo o mundo estão aumentando seus esforços para reduzir seus impactos ambientais por meio da implementação de sistemas de gestão ambiental. Essa linha de ação do setor aeroportuário, que está em vigor há não mais de quinze anos, tem por objetivo transformar o aeroporto no que é conhecido como "aeroporto verde". Ele é entendido como um aeroporto cujo projeto, operação e administração são realizados de forma que seu impacto ambiental seja o mínimo possível, tornando sua gestão sustentável. Portanto, este artigo apresenta uma estrutura geral para o desenvolvimento do conceito, bem como uma análise dos processos operacionais dos aeroportos que afetam negativamente o meio ambiente. Com base nisso, são sugeridas políticas, estratégias e processos de gerenciamento para minimizar ou cancelar esses efeitos negativos no ambiente do aeroporto, de modo a aproximá-lo do conceito de um "aeroporto verde".

Palavras-chave:
aeroporto verde, gestão ambiental de aeroportos, aeroportos sustentáveis

INTRODUCTION

Airports are one of the pillars of the global aviation industry. However, with their greenhouse gas emissions, they are not only significant contributors to the climate change that the world is currently experiencing (Postorino & Mantecchini, 2014), but also generate a wide variety of environmental impacts that affect both the physical environment and the health of communities that live in the vicinity of air terminals.

Nowadays, sustainability plays a central role in airport development programs, and growing environmental concerns demand that airport developments and operations are ecologically sustainable and that the industry is sustainable (Kumar et al., 2020; Votsi et al., 2014). Likewise, the global demand for air transport is growing after the COVID-19-imposed restrictions of 2020 and 2021. This means airports must grow and expand their capacity to absorb the expected mid and long-term demand. However, despite the common belief, it is not the financing or availability of land that slows down airport growth, but rather the environmental consequences of their infrastructure expansion that pose a challenge to their development (Ferrulli, 2016).

All this makes it clear that airport environmental sustainability is an emerging global concern (Korba et al., 2022). In this vein, the Airport Council International (ACI) – the international organization for the world's commercial airports - defines airport sustainability as a holistic approach to an airport's management to ensure its economic viability, operational efficiency, conservation of natural resources, and social responsibility (Airports Council International Europe, 2019). Therefore, airport sustainability can only be achieved with the right balance between socio-economic objectives within the limits imposed by the surroundings. This idea underlies the objective of this article, which is to present, from a holistic point of view, the concept and principles of a green airport and the general development framework behind the transformation into a green airport.

METHODOLOGY

The systematic mapping method was used for this work. This is the process of identifying, categorizing, and analyzing existing literature relevant to a given research topic (Carrizo & Moller, 2018; Salama et al., 2017). This review aims to show an overview of the related scientific field, in this case, that of green airports. This systematic mapping is done in three basic blocks: (a) first, defining the search, where the research question, scope of the review, inclusion/exclusion criteria, and finally, search chain, are determined; (b) the search is then done; and (c) third, the analysis and discussion of the results.

As far as the definition of the search is concerned, the research questions are those related to the fundamentals of the 'green airport' concept, namely: what are they or how are they defined? What are their development criteria? How are the related indicators managed? Is there a model or standard to transform an airport into a green one?

As for the scope of the review, it was done mainly between 2006 and 2023 (both inclusive). The argument behind this is that the 'green airport' concept was proposed for the first time in 2006. However, previous scientific literature that published works on 'environmentally sustainable airports' was also considered.

The review was carried out using a bibliographic search in the following digital catalogs: ScienceDirect, IEEE Xplore, Taylor & Francis, Springer, Wiley, SAGE, and JSTOR, for which the following descriptors were used: green airport, environmentally sustainable airports, sustainable airport construction, sustainable air operations, airport environmental impact, airport environmental mitigation, airport and climate change, airport environmental management, green airport accreditation.

On the other hand, the following inclusion/exclusion criteria were applied in the filtering process:

(a) all scientific publications that were only related to the concept of green airports were included;
(b) studies edited in English and Spanish were included;
(c) all studies that proposed guidelines and methodologies for achieving green airports were included;
(d) case studies were included as long as they provided a related conceptual framework and concrete, measurable, and comparable results;
(e) articles without a research design and a well-defined research question were excluded;
(f) third-party reviews were excluded;
(g) review papers were excluded;
(h) works on opinion polls or similar were excluded;
(i) technical reports and/or studies without a solid scientific basis were excluded;
(j) any 'grey literature' that did not have a solid,

rigorous, and formal theoretical foundation was excluded.

Two review filters were applied regarding the search: (a) the review of the article title and abstract and (b) a review of the full text.

Finally, the last step in the methodology is to present, contextualize, and analyze all the literature found and chosen, following the criteria to develop a green airport. This analysis was segmented by criteria to define a green airport's planning, construction, evolution, and management. These criteria, in turn, are discriminated by concepts and/or indicators directly related to an airport's different operational and management aspects. This segmentation in the analysis is necessary due to airports' tremendous operational complexity.

RESULTS AND DISCUSSION

THEMATIC MAPPING

First of all, and as a result of the extensive bibliographic review, a table is presented that synthesizes the review's thematic and/or concept mapping (Table 1). The description of the results, i.e., the categorization of the environmental impacts and corresponding mitigation strategies, will follow the pattern defined in Table 1.

DEFINITION

A green airport is one that has been designed, and both its operation and administration are run in such a way that its environmental impact is as low as possible to make its management sustainable (Airports Council International Europe, 2015; Ferrulli, 2016) and whose technological setup aims to ensure that all resources are used and managed in the most efficient way possible to generate the least environmental impact. To do this, the airport applies intelligent, collaborative, dynamic, and automated systems capable of responding to the daily needs of all its stakeholders.

In this line, a green airport should contemplate the following actions (Dalkiran et al., 2022; Kilkis & Kilkis, 2016):

a. Explore the different technological advances to improve energy efficiency to reduce consumption.
b. Favor the production of energy using renewable energy sources.
c. Collaborate with airport operators and concessionaires to develop and implement these measures.
d. Evaluate the feasibility, effectiveness, and profitability of these technologies and new operating procedures.
e. Validate that the commissioning of the different actions guarantees the operability and security of the airport.

Table 1: Thematic mapping of the literature review, segmented by an association between the environmental impact generated and the strategy used. Source: Preparation by the author.

Environmental strategy (considering the impact generated)	References
Noise mitigation measures for service vehicles and aircraft.	Fyhri & Aasvang (2010); Meister & Donatelle, (2000); Babisch (2006); Haines et al. (2002); Heinonen-Guzejev et al. (2007); Díaz Olariaga (2018); ICAO (2013); ICAO (2022); Karakoc et al., (2019); Licitra & Ascari, (2014); ACI (2022); ACI (2021); ACI (2020); ACI (2019).
Emissions reduction, air quality management, and energy efficiency.	Halpern & Graham (2018); Young & Wells (2019); Budd & Iverson (2017); Bamidele (2023); Karakoc et al., (2019); Čokorilo (2016); Monsalud et al., (2015); Postorino & Mantecchini (2014); ACA (2023); ACI (2022); ACI (2021); ACI (2020); ACI (2019).
Water management.	Guillamón (2010); Carvalho et al. (2013); Li et al., (2022); Young & Wells (2019); ACI (2022); ACI (2021); ACI (2020); ACI (2019).
Waste management.	Budd & Iverson (2017); Guillamón (2010); Kumar et al., (2016); Baxter (2022); ACI (2022); ACI (2021); ACI (2020); ACI (2019).
Sustainable design and construction.	Ferrulli (2016); Chang & Yeh (2016); Korba et al., (2022); ACI (2022); ACI (2021); ACI (2020); ACI (2019).
Management and monitoring of environmental processes (diverse topics/concepts).	Kumar et al. (2020); Budd & Iverson (2017); Dimitriou & Karagkouni (2022); Young & Wells (2019); Ferrulli (2016); ACI Europe (2015); Kilkis & Kilkis (2016); Dalkiran (2022); ACI Europe (2019); ACI Europe (2015); ACRP (2013); ACI (2022); ACI (2021); ACI (2020); ACI (2019).

Therefore, and in this vein, a green airport should be understood as an airport infrastructure whose management and operation are based on sustainability criteria, which, according to Airports Council International Europe (2015, 2019) and the National Academies of Sciences, Engineering, and Medicine (Haseman, 2013) implies that:

a. the organization has defined an environmental policy;
b. has an environmental management system following its environmental policy;
c. makes efficient use of available energy;
d. uses renewable energy sources in its facilities;
e. efficiently manages its solid waste and landfills;
f. makes rational use of water and other natural resources;
g. has procedures that minimize the impacts associated with operations;
h. has procedures to reduce greenhouse gas emissions and local pollutant emissions;
i. promotes good environmental practices and complies with local environmental legislation[1].

It can be seen, then, that these criteria focus on implementing technologies and technical methodologies that aim to reduce the negative environmental impacts of airports2. This vision is one of the prevailing environmental discourses in the industry for constructing a sustainability policy in aviation, emphasizing the ecological modernization of airports.

ENVIRONMENTAL IMPACTS GENERATED BY THE AIRPORT

The environmental quality in an airport's surroundings can be affected by multiple impacts associated with airport activity. Therefore, it is customary to segment them as follows, following what is proposed by Guillamón (2010), Young and Wells (2019), and Li et al. (2022):

a) Direct impacts are those from a direct consequence of the airport and its operation.
b) Indirect impacts are characterized by not being directly linked to the airport, although they are associated with its existence.
c) Induced impacts are those generated due to the airport's existence but not by the direct action of its installation or operation.

Based on this, an analysis is made that focuses on the environmental problems related to the airport and its operations.

NOISE

The noise generated by aircraft, whether from flyovers, during takeoff and landing, or when taxiing (runways, taxiways), is one of the most immediate and challenging environmental problems of the airport industry, as it is one of the factors that cause the immediate reaction of neighboring communities to the airport, on being a problem that affects the health and well-being of residents in their area of influence.

Epidemiological studies suggest that exposure to aircraft noise is related to specific adverse effects on the psychological, physiological, and cognitive performance of those affected, which include sleep disturbances and/or interruption (Fyhri & Aasvang, 2010), increased stress (Meister & Donatelle, 2000), hypertension (Babisch, 2006), reading difficulties for children and hearing loss (Haines et al., 2002).

Other studies claim that noise sensitivity may be a risk factor for people with cardiovascular problems (Heinonen-Guzejev et al., 2007). In short, limiting or reducing the number of people affected by noise is nowadays a key priority (Díaz Olariaga, 2018; Licitra & Ascari, 2014).

AIR QUALITY

Emissions of polluting gases such as CO_2, NO_x, and CO do not come exclusively from aircraft, either in flight or in their ground operations. The means of transport that facilitate access to the airport, the energy consumption (either gas or electricity), and the service vehicles that support airport operations, specifically in the area known as the 'airside,' are also significant sources of these pollutants. Together, these elements contribute to the degradation of air quality in the areas around the airport, as noted by Halpern and Graham (2018) and Young and Wells (2019).

1 Local environmental legislation is understood here as all the environmental criteria and/or requirements that, depending on the country, must be met so that an airport is not penalized in its operations or an expansion project or new airport is approved.

2 As an example or reference in a later subsection, figures on the positive impact on environmental indicators, results of the methodologies, and strategies implemented by airport managers are presented.

Even though air quality regulations differ between countries, airport managers document and communicate the emissions produced, categorizing them into the following sources, according to Budd and Iverson (2017):

a. Direct emissions originating from resources that are under the ownership or management of the airport, including vehicles operating on the airside or airport buildings;
b. Indirect emissions mainly associated with the acquisition of electricity generated elsewhere for use in airport facilities;
c. Other indirect emissions derived from the airport's activities, ranging from aircraft operations to the diverse means of transport that access the airport.

The third group (c) emissions constitute the most significant proportion of airport emissions, as Bamidele et al. indicate. (2023). However, these are also the emissions where the airport operator usually exercises little or no control.

Two primary sources of poor air quality have caught the attention of airport operators: land access to the airport and transport vehicle service on the air side of the airport. Concerning the former, the cooperation of local authorities is vital to encourage public transport to and from the airport and to implement renewable energies in their public transport systems (Janić, 2018). On the other hand, regarding the second source of pollution, it should be noted that many airports are already using electrically powered service vehicles on the airside.

GREENHOUSE GAS EMISSIONS

The airport power plant, the (service) vehicle fleet, the maintenance of airport infrastructure, the apron support equipment, emergency power equipment, waste disposal systems, etc., constitute significant sources of greenhouse gas emissions. In this sense, the elements that predominate in generating these gases at an airport include the air conditioning equipment of buildings, interior lighting, and assistance services to the aircraft on the apron. On the other hand, although they represent a smaller proportion, beaconing, apron lighting, and air navigation assistance equipment also contribute to the total cost of an airport's energy bill (Karakoc et al., 2019).

SOIL AND GROUNDWATER AND SURFACE WATER POLLUTION

Water pollution can result from a direct or indirect discharge of substances into streams or water bodies, which causes alterations in the properties of water's natural ecosystems and chemistry. Surface waters are the most vulnerable to pollution, as pollutants can be washed from the paved surfaces of the airport (runways, taxiways, and apron) into nearby streams, rivers, wetlands, and lakes. Groundwater can also be affected when leaks or spills of industrial liquids infiltrate the soil (Guillamón, 2010; Santa et al., 2020).

WASTE GENERATION

Airports generate different types of hazardous and non-hazardous waste due to their varied operations (Budd & Iverson, 2017; Guillamón, 2010). These can be classified into:

a. Hazardous waste derived from maintenance facilities.
b. Organic and inorganic waste produced by airport concessionaires, such as shops.
c. Non-necessarily toxic inorganic waste generated by the airport administrative offices.
d. Items confiscated at security checks and in checked baggage.
e. Organic products, such as different types of food confiscated at customs controls.
f. Waste generated during aircraft cleaning operations.
g. Waste originating from construction and civil works at the airport.
h. Industrial waste.
i. Wastewater and stormwater that has been contaminated.

ENVIRONMENTAL MANAGEMENT STRATEGIES

In addition to providing obvious environmental benefits, effective strategies supported by public policies, programs, and measures should allow for better anticipation and rapid resolution of environmental problems without affecting economic performance or business opportunities (Budd & Iverson, 2017). In the specific case of airports, these strategies can be focused on improving environmental management, monitoring, and operational practices (Dimitriou & Karagkouni, 2022; Young & Wells, 2019).

NOISE POLLUTION CONTROL

Noise pollution is one of the primary sources of complaints and grievances by residents living near airports. To reduce noise emissions from primary operations, such as takeoffs and landings, airports worldwide have been gradually implementing the 'balanced approach' criteria promoted by the *International Civil Aviation Organization* (ICAO, 2014). This approach comprises four key elements:

1. Noise reduction at the source.
2. Operational procedures for noise attenuation.
3. Land use management and planning.
4. Introduction of operational restrictions.

For the first element, the aeronautical industry has been working for years on designing and constructing quieter engines, an area that airports have no competence or control over (International Civil Aviation Organization, 2022; Karakoc et al., 2019).

The third element is also beyond the competence and control of the airport, as the management of land use in the vicinity of the airport depends exclusively on the local authorities. However, the airport does have competence and control over the second and fourth elements. In particular, introducing operational restrictions, to the fourth element, is currently the most applied tactic in the largest airports in the world (Licitra & Ascari, 2014).

AIR QUALITY CONTROL

Since the harmful effects of the primary air pollutants produced by airport operations were recognized, governments and international organizations have developed regulations and programs to minimize their adverse impact on health and the environment. Therefore, monitoring programs must be designed with regard to the following conditions (Čokorilo, 2016):

a. It is always possible to know the contamination values reliably and immediately, complying with the standardized and accredited values.
b. That allows determining the atmospheric dispersion processes of pollutants using the correct location of the monitoring stations.
c. If the data are significant, the specific pollution crises can be controlled and their evolution analyzed.

Simultaneously, the airport can improve local air quality by applying different measures depending on the specific source of the pollutants (Greer et al., 2020; Karakoc et al., 2022).

CONTROL OF GREENHOUSE GAS EMISSIONS

To control polluting emissions, airports have begun to modernize power, heating, and cooling plants to improve efficiency while innovating by generating energy from renewable sources. Similarly, airport buildings are being designed (or redesigned) to be 'smart' and energy efficient, which puts them on par with specific international standards (Karakoc et al., 2019).

While some airports have already started working on 'energy efficiency,' this is not yet standard in airport infrastructure design. It is understood that energy efficiency is a set of intelligent measures applied to a specific environment that allows energy savings in any of its forms while maintaining the energy system's quality and service levels of said environment without compromising the established objectives. Sustainable energy use necessarily implies improving energy efficiency, which leads to decreased greenhouse gas emissions (Monsalud et al., 2015). Thus, according to Postorino and Mantecchini (2014), energy efficiency in an airport infrastructure should a) guarantee the safety and operability of the airport, b) contribute to the transport of passengers and goods, and c) improve the energy efficiency of the processes that are part of its activity.

In this sense, airports increasingly opt for the Airport Carbon Accreditation (ACA, 2023) program certification, the only global carbon management certification program for airports institutionally supported by the Airports Council International (ACI). The ACA provides a single common framework and tool for active carbon management at airports with measurable results, covering the operational activities that contribute most to carbon emissions.

The *Airport Carbon Accreditation* evaluates and recognizes the efforts of airports to manage and reduce their carbon emissions through six levels of certification or accreditation, which are graphed in Figure 1: 'mapping' (carbon footprint measurement), 'reduction' (carbon footprint reduction management), 'optimization' (third-party participation in carbon footprint reduction), 'neutrality' (carbon neutrality for direct emissions through trade-offs), 'transformation' (transformation of airport operations and those of its trading partners to achieve absolute reductions of emissions), and 'transition' (counteracting residual emissions through reliable trade-offs) (ACA, 2023).

WATER QUALITY CONTROL

Airports consume significant amounts of water to provide essential services to passengers, employees, visitors, and other facilities, equipment, and infrastructure. Currently, water is no longer perceived as an unlimited resource, and the cost of its supply is increasing, so airports are managing water consumption to reduce costs and as part of their sustainable development strategy.

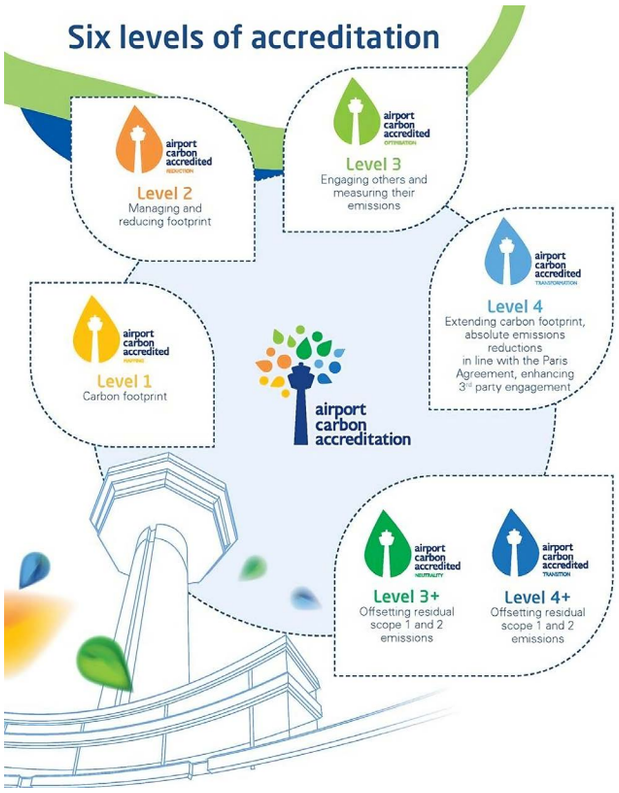

Figure 1: Carbon management accreditation levels for airports. Source: Airport Carbon Accreditation (https://www.airportcarbonaccreditation.org/)

In terms of resource management, there are two fundamental approaches to drinking water conservation: on the one hand, reducing its use and, on the other, replacing drinking water from the network with other sources, such as rainwater collection and reuse, wastewater treatment and cooling water recycling (Carvalho et al., 2013; Guillamón, 2010; Li et al., 2022; Young & Wells, 2019).

OPTIMAL WASTE MANAGEMENT

Baxter (2022) points out that the primary intention of airports regarding environmental practices is to reduce waste generation, which results in a positive image for the airport. In this sense, Guillamón (2010) shows that airports have been working at three hierarchical levels to manage generated waste efficiently. The first is to prevent waste generation to avoid unnecessary production. The second level is implementing reuse policies, and the third is establishing recycling strategies.

Waste management is a critical environmental problem that airports must face worldwide (Baxter et al., 2018). The solid and hazardous waste produced by airports can mainly be processed in three ways: recycling, incineration, and landfill disposal. Thanks to innovation, waste is increasingly being considered a resource to be optimized, thus minimizing its negative environmental impact.

The waste hierarchy approach focuses on its prevention, which is a crucial pillar in the green economy and contributes to improving efficiency in the use of resources and reducing the need for raw materials. This hierarchy starts with prevention and continues with reuse, recycling, recovery, and finally disposal (Kumar et al., 2016).

SUSTAINABLE DESIGN AND CONSTRUCTION

The design and construction of airport infrastructures are challenging for contemporary airport engineering due to the need to consider environmental concerns (Ferrulli, 2016). For this reason, airports should be developed so that environmental constraints do not affect operational capacity and future development. On the other hand, airport authorities can implement green building practices to make airport buildings more environmentally friendly (Chang & Yeh, 2016).

ENVIRONMENTAL PROCESS MANAGEMENT AND MONITORING

Public and political pressure and legislation tightening have led the airport industry to pay greater attention to environmental mitigation. From this, environmental management, monitoring, and operational processes have been deeply integrated into the business strategies of most airport operators.

Similarly, environmental management systems have been widely adopted to provide benchmarks to ensure coordinated responses to various environmental problems. That is why implementing reliable and replicable monitoring regimes is vital to environmental impact assessments and management systems (Kumar et al., 2020).

IMPACT OF ENVIRONMENTAL MANAGEMENT ON INDICATORS

During at least the last two decades, many of the world's airports have begun implementing actions and strategies to become environmentally sustainable infrastructures. As mentioned, airport managers must work in several operational areas, with medium and long-term plans that require significant capital investments to improve the different environmental indicators affected by airport activity. To illustrate the potential of how airport managers can positively impact environmental indicators with their actions and strategies, Table 2 presents statistics of recent experiences of several medium and large international airports that handle 20 to 40 million passengers annually in different regions of the world.

Table 2: Impact of the airport's environmental strategies on the indicators. Reference figures in medium-large international airports (which handle between 20 and 40 million passengers/year) in the last four years. Source: Airports Council International, 2022; Airports Council International, 2021; Airports Council International, 2020; Airports Council International, 2019.

Indicator	Action / Strategy	Reduction / Saving
Emissions	Electric buses and service vehicles on the airside	91% reduction of emissions per year (342 T of CO_2/year; 202 Kg of NOx/year)
Emissions	Advanced air conditioning control system in the Passenger Terminal	Savings of 1.7 million kWh/year and 630 T of CO_2
Emissions	Use of LED lights in Passenger Terminal	32% reduction of CO_2 emissions/year
Emissions	Clean geothermal heating and cooling system (for Passenger terminal)	83% reduction of CO_2 emissions/year
Emissions	Use of LED lights on the runways/taxiways	Reduction of CO_2 emissions (for two runways): 712 T of CO_2/year.
Emissions	Solar-powered ground support equipment for aircraft	Annual reduction of 102,209 liters of diesel and emissions: NOx (1,672 kg); CO (965 kg); PM (190 kg).
Electricity	Implementation of energy efficiency program (for the entire airport)	26% reduction in electricity consumption per year
Air quality	Installation of continuous monitoring stations for ambient air quality	12.5% annual reduction of emissions (including gaseous and particulate matter)
Air quality	Implementation of an air quality management system	Reduction of concentrations (per year): SO_2 49%, NOx 6.7%, NO_2 11.7%, PM10 27.6%, PM2.5 26.3%
Air quality	Air pollutant reduction plan	Annual reduction: 10.1 T of TSP, 1.7 T of PM10, 1.2 T of PM2.5, 59.9 T of NOx, 36.1 T of SOx, 49.9 T of CO, and 12.5 T of non-methane hydrocarbons.
Aviation fuel	Taxiing of aircraft on the ground with a single engine	Saving 4,382 kl of fuel/year
Water	Implementation of a water management system	30.92% efficiency in the use of water. Internal resources such as treated wastewater and surface water cover 50% of the airport's water demand.
Water	Rainwater recycling system	Reduction of 50% of the total network water used inside the passenger terminal.
Water	Dry cleaning of aircraft	90% reduction of water use.
Water	Installation of high-efficiency cooling towers	Reduction of 72,154 tons/year of water consumption in the passenger terminal.
Waste	Waste minimization system through composting and organic waste treatment	Annual reduction of 238 T CO_2, avoiding the dumping of 353 MT/year of waste from food in landfills, generating 276 MT of fertilizers for landscaping and horticulture.
Waste	Waste management and recycling system	57% overall reduction in waste going to landfills.
Waste	Waste separation and recycling system	30.8% of general waste is recycled. 93.7% of the waste disposed of is used as a waste-derived fuel for cement production.

CONCLUSIONS

The extensive thematic review of the 'green airport' concept shows some convergence among academics regarding the structure or development framework on which airport management should be based to achieve environmental sustainability. The course of action proposed by most studies and research begins by identifying the environmental aspects negatively affected by airport activity. Then, the source of the environmental impacts is identified, and finally, actions, strategies, and methods are formulated to mitigate or offset the generated impacts.

A common denominator of the literature analyzed is the recommendation that an airport should be environmentally sustainable or 'green,' and airport managers should implement ecological practices in their core competencies due to strict environmental standards and strict regulations (required in their respective countries). The growing competition has drawn the attention of airport authorities worldwide to adopt green practices in their organizational and operational activities.

In short, airports may be limited by environmental issues that restrict current operations and limit future potential growth. To maximize growth opportunities, it is necessary to consider all the factors involved in the construction and operation of an airport to avoid environmental impacts that impact sustainability strategies. The life cycle and long-term planning of airport infrastructures require a systemic approach to meet the need for change through a better definition of management processes and compliance with environmental sustainability requirements.

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