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Review

Sustainability in the Airports Ecosystem: A Literature Review

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Abstract: The global challenges of sustainability are transforming the economy of the 21st Century. Economic, social, and environmental sustainability impacts regulators and businesses, particularly in the aviation industry, and facilitates access to productive services and market linkages. Airport stakeholders are increasingly pressuring companies to consider their socioeconomic impacts and manage them sustainably and resiliently. Business is paramount to airport companies in this competitive and economically sensitive climate. Many studies have addressed the issue of airport sustainability from specific perspectives. These perspectives include economic sustainability, benefits related to economic and environmental sustainability, and the impact of operations on the airport environment. This report summarises the current state of airport environmental sustainability practices, including greenhouse gas emissions from airport pavements, energy management strategies for airport buildings and operations, water conservation, and waste management. We aim to provide a clear and integrative picture of these impacts on airport sustainability through a systematic literature review while advancing knowledge A systematic literature review was performed using the PRISMA guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology. This systematic literature review sought to consolidate knowledge on the subject. In order to illustrate the link between major categories and their corresponding trends, authors used VOSviewer scientific software. The compilation of existing knowledge on the three components of sustainability likely underscores the importance of overall airport sustainability. It is suggested that further studies be conducted.

Keywords: sustainability; airports; aviation; SRL; PRISMA

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1. Introduction

Airport infrastructure is essential to society's transportation network and presents key environmental challenges. Massive investments are required to modernise and rehabilitate the ageing and inadequate airport infrastructure and prepare for handling passengers worldwide, according to COVID-19 [1]. The environmental impact of building and operating an airport is considerable, especially considering that the aviation industry is responsible for significant global greenhouse gas emissions, not including the impact of airport construction and operations [2].

In public policy, airport sustainability is an emerging area of interest. This report provides a much-needed overview of relevant sustainability indicators and methodologies for airport infrastructure. In addition, the expected increase in demand for air travel will exacerbate the environmental impacts of airport construction and operation [3].

Sustainability is about managing the resources of today's society in a way that does not compromise the needs of future society. The triple-bottom-line approach aims to achieve sustainability. Sustainability indicators or metrics can be used to measure an airport's sustainability performance. These indicators are critical for making decisions about airport infrastructure's sustainable design and operation [1].

In addition, the aviation industry defines airport sustainability as a triple-bottom-line concept with a fourth pillar focused on operational efficiency. Airport sustainability includes general sustainability, energy supply, strategies for reducing greenhouse gas emissions, air quality impacts, water management, ground transportation, sustainable construction, and waste management [3].

Therefore, the definition of airport environmental sustainability varies in the academic literature, with some defining it based on multiple categories of environmental impacts and others limiting this definition to the traditional environmental impacts of aviation [1]. The airside and landside components of the airport system often summarise environmental impacts. This article helps identify the most significant environmental impacts and how they can be mitigated. This literature review on airport and aviation environmental sustainability identifies gaps and provides recommendations for future research directions.

2. Materials and Methods

Methodology

The research conducted in this study follows a systematic literature review approach, which enables the establishment of a research framework developed from a scientific standpoint. This methodology ensures transparency, replicability, and a scientific process that aims to minimise biases by extensively exploring published papers and unpublished studies. After formulating the research questions, the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology was employed. The process of selecting reference papers consists of four stages: (1) selecting relevant databases, (2) extracting papers, (3) screening abstracts, and (4) screening full-text articles. The selection process is outlined using the PRISMA 2020 flow diagram (Figure 1) (Moher et al., 2009). The study formulated three research questions about entrepreneurship, airports, and sustainability. The Scopus database by Elsevier and the Web of Science (WoS) database by Clarivate were consulted for this study.

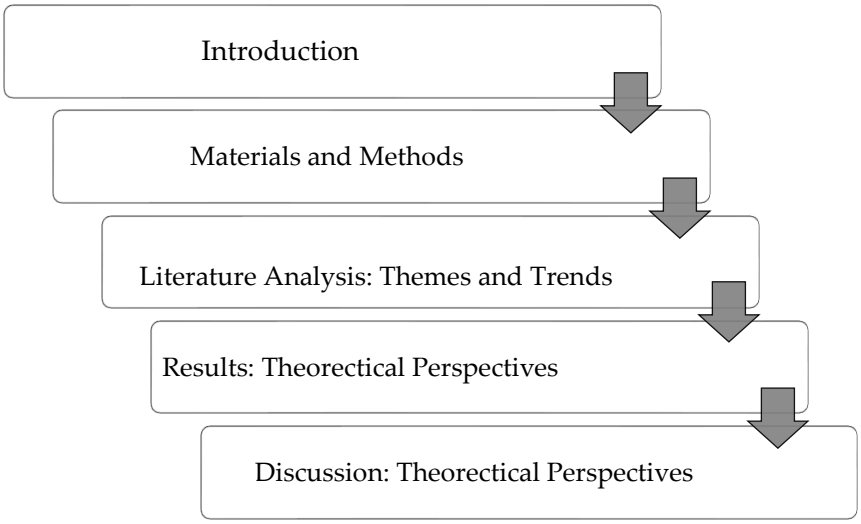

Figure 1. Research Design (*Source:* own elaboration).

The research methodology began by using the keyword "airport entrepreneurship" in abstracts, combined with the Boolean term "OR" and the keyword "Sustainability", as it was observed that researchers use these terms interchangeably to refer to the same concept. Additionally, the keyword "entrepreneurs" was included using the Boolean term "OR", as we aimed to examine small businesses. Furthermore, the research was specifically limited to scientific articles with peer review (LIMIT-TO DOCTYPE, "ar") to ensure consistency in the search process.

In total, 65 potentially relevant contributions were identified in the "Scopus" database, while 71 were found in the "Web of Science" database. Only scientific papers written in English and published in business and management were selected for further analysis (Figure 2).

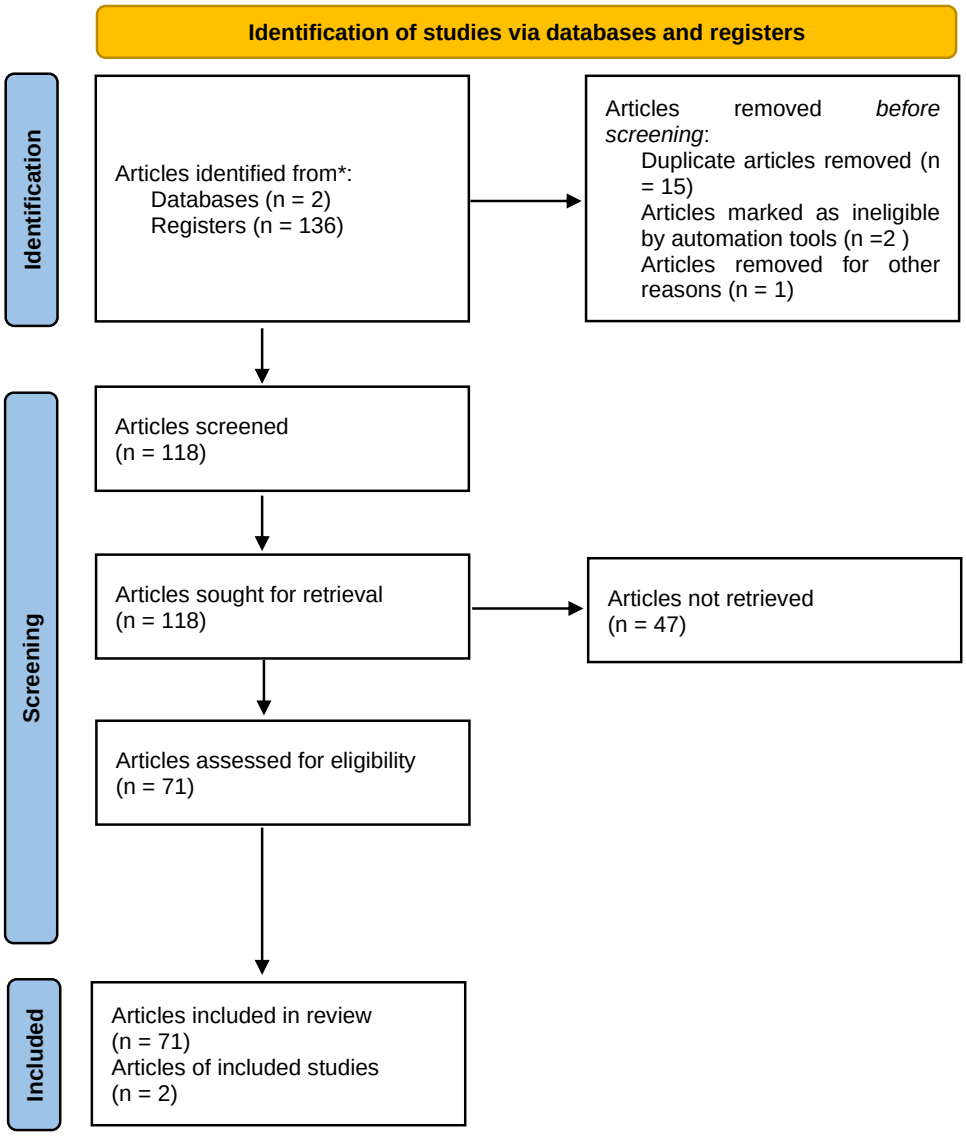

Figure 2. PRISMA 2020 flow diagram (source: own elaboration). (* Scopus and WoS).

To illustrate the link between major categories and their corresponding trends, the authors used VOSviewer scientific software. VOSviewer is a software tool for creating maps based on network data and for visualising and exploring these maps (Waltman et al., 2010). Items may be grouped into clusters. A cluster is a set of items included in a map. Clusters are non-overlapping in VOSviewer. In other words, an item may belong to only one cluster. Clusters do not need to exhaustively cover all items in a map (Waltman et al. 2010). Hence, there may be items that do not belong to any cluster.

According to the literature review protocol, a step-by-step methodological approach was adopted to ensure that the data gathered and analysed are accurate, reliable, and applicable. In this sense, the review of bibliometric literature (LRSB) involves the screening and selection of information sources to ensure the validity and accuracy of the interpreted and presented data, and the process was divided into 3 phases and 6 steps [4–10] (Table 1).

Table 1. Process of systematic LRSB. (Source: [4–10]).

Fase	Step	Description
Exploration	Step 1	Formulating the research problem
	Step 2	Searching for appropriate literature
	Step 3	Critical appraisal of the selected studies
	Step 4	Data synthesis from individual sources
Interpretation	Step 5	Reporting findings and recommendations
Communication	Step 6	Presentation of the LRSB report

The methodology approach began with a literature search on the SCOPUS indexing online database of scientific articles, the most important peer-reviewed platform in the academic world and the WebScience Database. Nevertheless, we consider that the study has the limitation of being based only on the SCOPUS database and Web of Science excluding other academic databases which reflect a methodological choice.

3. Literature Analysis: Themes and Trends

In the past years, peer-reviewed documents on the subject have been increasing. The number of publications in the related field over the past years shows that academic opinion and interest in this field have increased. Therefore, it is expected that there will be some developments that trigger academic interest in practical life. This analysis allows us to understand that 2021 and 2022 were the year about 3800, the highest number of peer-reviewed documents on the subject. Since 2010 the interest in research on SME sustainability in the Airports Ecosystem has been increasing (Figure 3). Even though the pandemic outbreak of Covid 19 was in 2020, it is possible to observe an increasing trend.

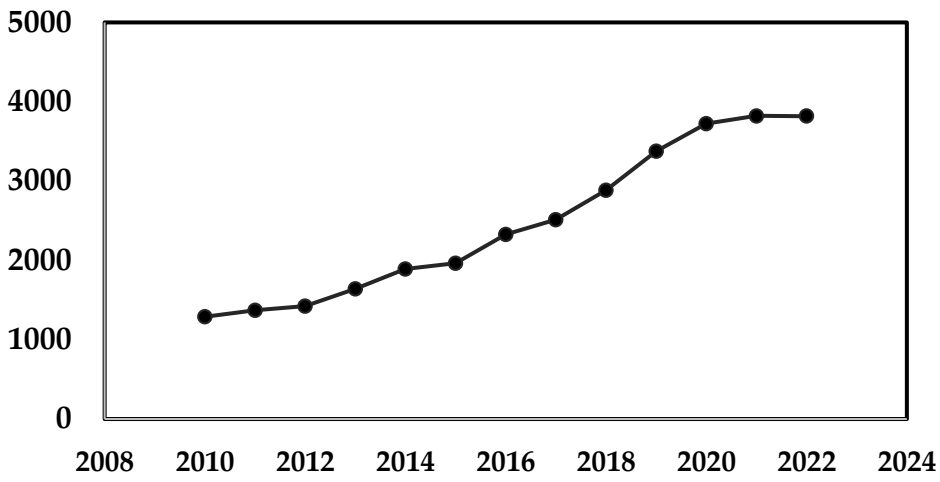

Figure 3. Documents by year (Source: own elaboration).

Among all analysed journals, the Journal of Air Transport Management, with 709 articles, has the highest number of published articles on SME's sustainability in the Airports Ecosystem, followed by Small Business Economics, International Journal of Entrepreneurship and Small Business, Journal of Cleaner Production, Journal of Business Research and International Journal of Entrepreneurial Behaviour Research (Figure 4).

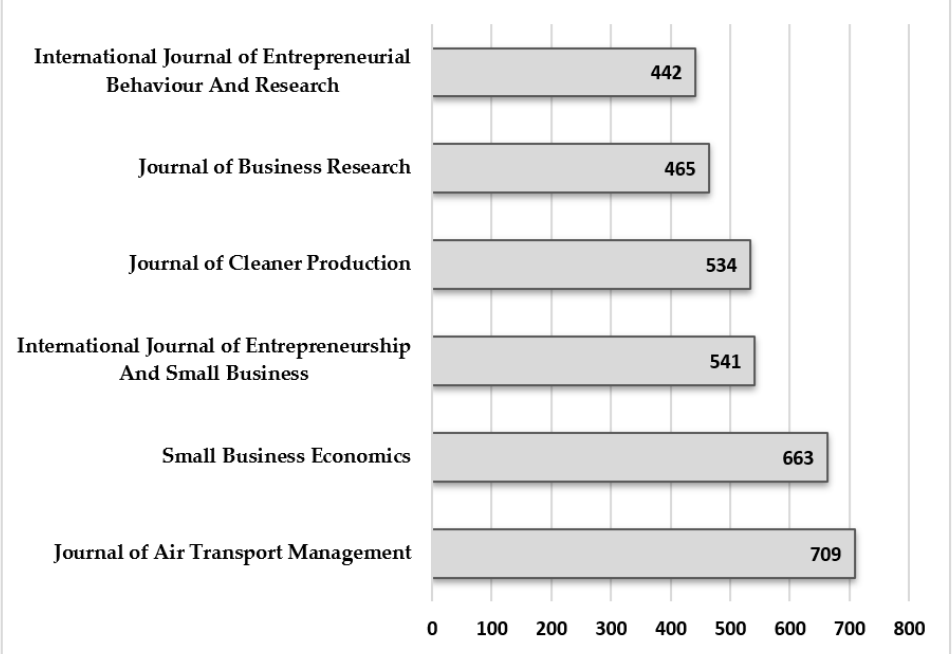

Figure 4. Documents per year by source (Source: own elaboration).

Considering the six journals with the highest number of research publications, we observe that the number of Documents per year by source is high, indicating a significant interest in entrepreneurship topics in the airport environment (Figure 4).

When researched by the author, it is possible to observe that Kraus, Audretsch, Ratten, Dana, and Williams as the authors with more than 70 published articles in the field understudy (Figure 5).

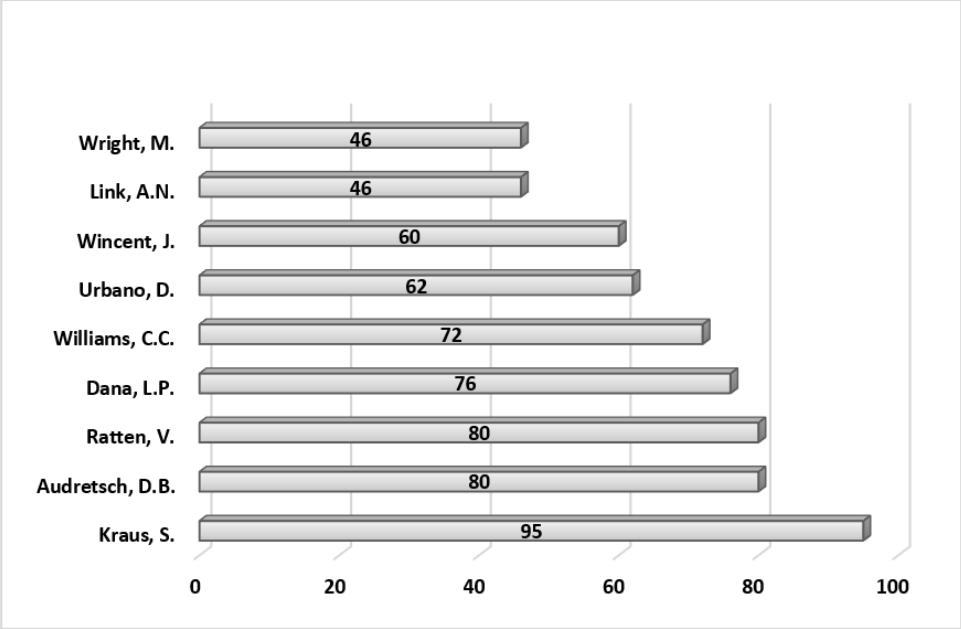

Figure 5. Documents per author (Source: own elaboration).

The geographical distribution of countries according to the number of published documents on sustainable entrepreneurship in airports is represented in Figure 6. It was noticed that the United States is most dedicated to studying business in airports and their sustainability.

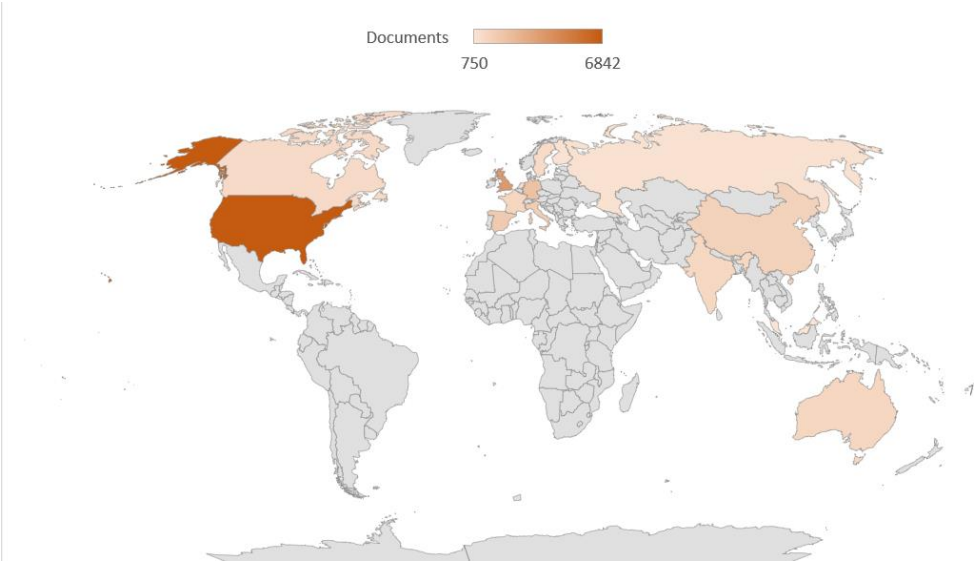

Figure 6. Geographical distribution of countries according to the number of published documents on sustainable entrepreneurship in airports. Source: own elaboration).

Table 2 analyses the Journal impact factor and best quartile supported by this review. As evident from Table 2, most articles on Sustainable airport Entrepreneurship rank on the Q1 best quartile index.

Table 2. Journal impact factor and best quartile. (Source: own elaboration).

Title	Best Quartile *	Fields *	Impact Factor (5-Year)
Journal of Environmental Management	Q1	Environmental Science	8.549
Transportation Research Record	Q2	Engineering	2.005
Technology and Innovation Management	-		-
Transportation Science & Technology	Q4		1.799
Environmental Research Letters	Q1	Environmental Science	8.414
Sustainability	Q2	Environmental Science	4.089
Business Strategy And The Environment	Q1	Business, Management and Accounting	11.604
Journal of Air Transport Management	Q1	Social Sciences	4.799
Journal of Cleaner Production	Q1	Business, Management and Accountin	11.016
International Journal of Information Management	Q1	Business, Management and Accounting	16.56

Table 2. *Cont.*

Title	Best Quartile *	Fields *	Impact Factor (5-Year)
Journal of Transport Geography	Q1	Social Sciences (transportation)	6.524
Promet-traffic & transportation	Q4	-	1.053
International journal of integrated engineering	Q3	Engineering	-
Energy	Q1	Energy	8.234
Logforum	Q2	Business, Management and Accounting	-
Journal of Optimization Theory and Applications	Q2	Decision Sciences	2.111
Megaron	Q3	-	-
International Journal of Sustainable Aviation	Q4	-	-
Sensors	Q2	Engineering	4.05
Resources Conservation and Recycling	Q1	Environmental Science	13.543
Total Quality Management & Business Excellence	Q1	Business, Management and Accounting	4.056
Turismo-Estudos e Praticas	Q4	-	-
Journal of Intelligent & Robotic Systems	Q3	-	3.071
Jurnal Teknologi-Sciences & Engineering	Q3	Engineering	-
Journal of Advanced Transportation	Q2	Business, Management and Accounting	2.502
Aeronautical Journal	Q2	Engineering	1.229
Zeitschrift Fur Semiotik	Q4	Social Sciences	-
Pamukkale University Journal of Engineering Sciences-Pamukkale Universitesi Muhendislik Bilimleri Dergisi	Q4	-	-
Journal of Environmental Protection and Ecology	Q3	Environmental Science	-
Frontiers in Psychology	Q2	Psychology	4.426
Transport Policy	Q1	Social Sciences	6.228
Journal of Arid Environments	Q2	Earth and Planetary Sciences	2.837
Computers & Industrial Engineering	Q1	Engineering	6.876
Ocean & Coastal Management	Q1	Environmental Science	4.101

Table 2. *Cont.*

Title	Best Quartile *	Fields *	Impact Factor (5-Year)
Ecosphere	Q1	Environmental Science	4.057
Biological Conservation	Q1	Environmental Science	7.396
Aircraft Engineering and Aerospace Technology	Q3	Engineering	1.293
Transportation Research Part A-Policy and Practice	Q1	Social Sciences	7.462
Journal of Geophysical Research-Solid Earth	Q1	Earth and Planetary Sciences	5.006
Problemy Ekorozwoju	Q4	Energy	0.956

Note: - data not available, * according Scimago Journal & Country Rank.

The Impact Factor (5-year) is a metric used to ascertain the productivity and impact of the published work, evaluate the influence of scientific journals, and consider citations over five years. In Figure 7, the bibliometric study is displayed to investigate and identify indicators of the dynamics and evolution of scientific information. Using the scientific software VOSviewer, the study of bibliometric results aims to identify the main research keywords in studies of SMEs' sustainability in the Airports Ecosystem.

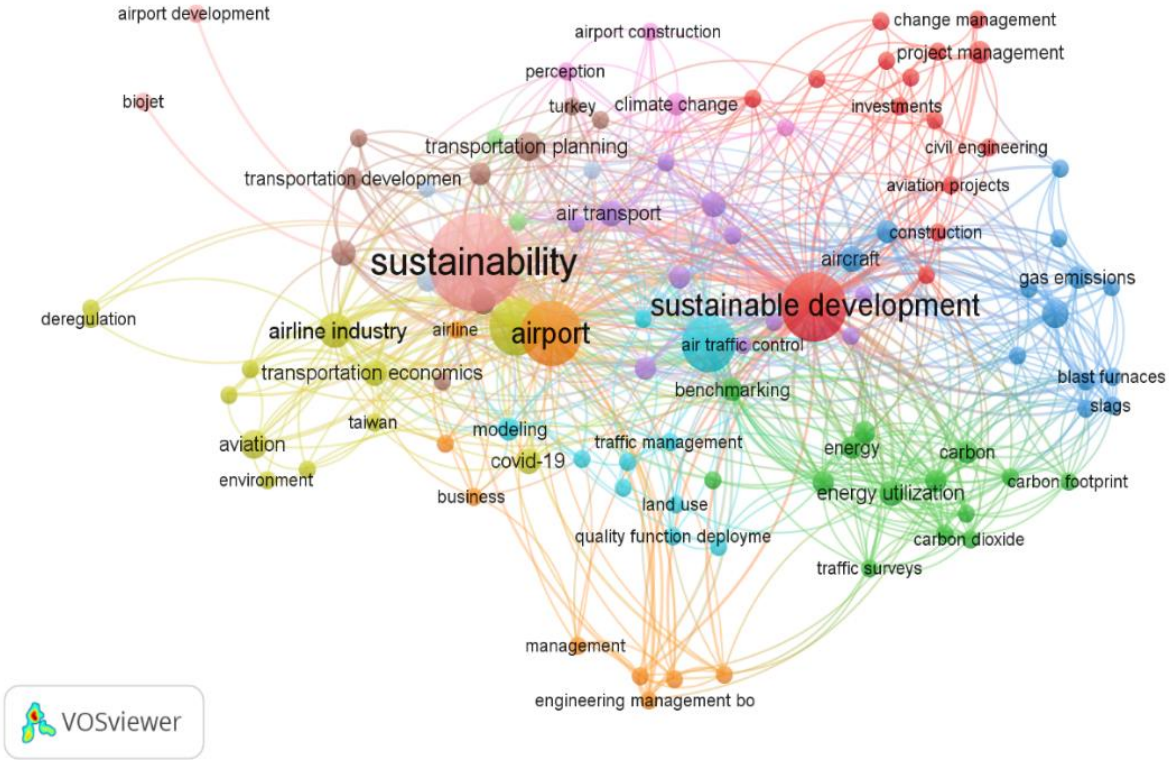

Figure 7. Network of all keywords. (Source: own elaboration).

The associated keywords can be examined in Figure 7, making clear the network of keywords that appear together/linked in each scientific article, thus allowing us to know the topics studied by the researchers and identify future research trends. The analysis included keywords provided by the authors of the articles that appeared more than ten

times. VOSviewer was utilised to generate network visualisations for the bibliometric study of nine clusters. The most frequently appearing keywords were "sustainability", "sustainable development", and "airport", which represent the main terms.

4. Discussion: Theoretical Perspectives

4.1. Airports

Airports have economic, environmental, and social impacts on communities. Adoption of social sustainability practices varies among small hub airports and focuses on four categories of stakeholders: Passengers and travellers, employees, communities and local businesses, and concessionaires and tenants [1]. Some studies compare the world's leading airports based on passenger surveys, sustainability performance, and differences in sustainability indicators according to sustainability reports prepared according to GRI guidelines [2]. Others analyse airport efficiency and economic sustainability using the DEA (Data Envelopment Analysis) method and conclude that airport size, the presence of low-cost airlines, and cargo volumes significantly impact efficiency and economic sustainability, with DEA by means of the basis of multiple inputs and outputs it is possible to measure the relative efficiency of decision-making units. The efficiency of a unit is defined as the weighted sum of its outputs divided by a weighted sum of its inputs, the weights for inputs and outputs are estimated by a linear programming so as to maximize the relative efficiency of each unit. numerous applications employing the DEA methodology have been proposed, and they involve several contexts. Actually, it is designed to evaluate data management units (DMUs) that use multiple inputs to produce multiple outputs without a clear identification of the relation between them, but it has then progressed throughout a variety of formulations and applications to other kinds of industries [3]. The key operational aspects of the airport industry are examined to assess the degree of responsibility of airport managers in disclosing corporate information about the economic, environmental, and social performance of airports, suggesting that customer orientation, economic viability, and business readiness are operational aspects of great importance [4]. Therefore, airport management needs to develop an effective business program to improve the existing system's performance [5]. In summary, airport performance needs to be evaluated for airports [6].

4.2. Sustainability and Sustainable Development

Sustainability has become a focus for practitioners and academics due to increasing socioeconomic problems. In Southeast Asia, airport operators have adopted sustainable practices to reduce carbon emissions, reduce waste and wastewater, increase economic contribution, meet passenger needs, and satisfy employee needs. Adopting new technologies for sustainable practices has been slow [7]. New airport operational sustainability definitions have been developed to help airports develop sustainable management plans, identify problems, and set performance targets [8]. In developing countries, sustainability and resilience strategies become less important when economic problems and high workloads come into play. However, passengers perceive an airport's sustainability activities and ethical core and are willing to use airport services again in their future trips [9]. Some studies investigated the impact of corporate social responsibility (CSR) implementation on the reputation of Incheon International Airport and found that CSR positively impacts reputation. Therefore, CSR activities can positively influence customer perceptions, strengthen the importance of sustainability, and play an important role in the Korean airport industry [10]. As a result, sustainability has become as important as management in business, and there is no consensus on a methodology to ensure sustainability in pavement life cycle assessment and analysis. Studies are needed to explore sustainability, explain its importance, and provide research recommendations [11].

Sustainability is an appropriate means to evaluate the performance of airports to ensure sustainable development. The aim is to integrate qualitative and quantitative information with the balanced scorecard for sustainability and use influential network-

relationship maps to evaluate the main influences on the performance of international airports in terms of sustainability [12]. Some research has developed an airport sustainability ranking index that uses 5 dimensions and 25 indicators to assess airport performance on multiple factors. The index can help airport managers coordinate strategies for sustainable energy, water, and environmental development [13]. In summary, airports' dependency level is important from economic geography and risk management perspective, as it can provide information on the sustainability and viability of financing airport projects [14].

4.3. Airline Industry

Global sustainability challenges are transforming the 21st century economy, and the role of sustainability in the airline industry ecosystem requires a systems approach and assessment tool for airport strategy [15]. Airlines have traditionally been the main players in deciding which new flights to open at a given airport. Still, introducing low-cost airlines has changed the reciprocal role of airlines and airports by requiring forecasting of passenger flows at an airport and the impact of a change in schedule on surrounding airports [16].

Some argue that the introduction of low-cost airlines and the increase in the density of regional and secondary airports in many European countries has changed the mutual role of airlines and airports. Today, airports must demonstrate the sustainability of new routes and forecast the economic impact on their catchment area [17]. Others focused on evaluating the reliability of the multistage flight network's (MSFN) flight network considering the time and number of stopovers and developed a search method instead of specifying all minimum capacity vectors in advance. A Ho Chi Mirth City case study of Taipei presents the solution method [18]. The developed trajectory-based flight operation allows airlines to fly on optimised routes without intermediate landing points and increase the sustainability of the air transportation system. However, volatile weather conditions and uncertain weather forecasts may require re-optimising trajectories during the flight. In some cases, fuel savings between 0.5% and 7% per flight have been achieved [19].

Some research addresses cases of reputation and stakeholder management in the transition to sustainability, focusing on aviation biofuel (biokerosene) and how airlines, airports, and bio-kerosene suppliers collaborate in the process of mutual strategic positioning that supports trust building and market development while promoting positive stakeholder perceptions [20]. Airlines and passengers are in tension with each other due to the complex supplier-customer structure that requires a multi-level Quality Function Deployment (QFD) model to find a compromise between airline and passenger requirements and ensure the generality and sustainability of the quality implementation [21].

Other literature sources indicate that aviation is a multicultural business environment, and its management requires a high awareness of human factor risks. The objective is to develop a human risk mapping model that considers the interrelationships among risk factors based on a multidimensional approach. Include a new risk mapping model focusing on organisational behaviour and culture to address ergonomic issues in the risk management system. The human factor determines the outcome in any organisation and any decision-making. New models can be useful for managing ergonomic human factors-based risks in aviation maintenance, such as the risk matrix, which contributes to the aviation management and strategy literature [22].

On the other hand, others suggest that risk knowledge has a direct influence on air travel behaviour, with an indirect influence via risk perception [23], e.g., the current drivers of demand for long-distance passenger travel in Europe and its environmental impact, while long-haul air travel is increasing at an unacceptable rate [24]. Green life cycle management is also a systems engineering approach to improve the environmental sustainability of the aviation sector [25]. At the same time, the challenges, opportunities, and key research priorities are discussed [26].

In contrast, in less developed countries, the aviation industry is growing rapidly, but airlines are regularly experiencing financial difficulties. A multi-criteria decision-making (MCDM) approach is used to identify key factors and rank them by their relative im-

portance, revealing that financial factors—e.g., utilisation factor—are the most important and operating revenue per mile is the key variable for this sector [27]. Furthermore, the explosion of e-commerce has increased the number of transportation requests worldwide, increasing the capacity of communication channels, warehouse space, and pollution, ultimately affecting environmental sustainability [28].

Finally, the number of domestic and international air passengers will reach six billion by 2030, leading to negative impacts, such as on the environment. The goal is to develop new air traffic management and load measurement systems for operators to reduce environmental impacts, carbon emissions, greenhouse gas emissions, noise pollution, and operating costs [29]. In the United Kingdom, privatised utilities and infrastructure providers have increased labour productivity, lowered prices, improved service quality, and significantly contributed to public finances. Still, the long-term problems remain to be solved [30].

4.4. Construction

In urban planning, the linkage between urban architecture, technology, neighbourhood management, and the social infrastructure of neighbourhoods is certain. In contrast, social conditions are important in mediating, facilitating, and integrating urban planning discourses [31]. To illustrate, the Okavango Delta is one of Botswana's leading tourism areas. It has encouraged the development of associated infrastructure and facilities, including hotels, lodges and camps, airports and airstrips, and other communication facilities in the Ngamiland district. Nevertheless, tourism is beginning to impact the environment negatively [32].

In today's society, protected areas are expected to justify their existence through the services they provide to society. Tourist data provide a reproducible case study for a better understanding of the sustainability of parks, improving key elements such as location, biodiversity, infrastructure, and cost of camp accommodation. It is thus important to highlight the complex interplay between ecological and built infrastructure [33], examine landscape design challenges in suburban areas, and discuss planned megaprojects and their implications for future sustainability in mitigation [34].

Noteworthy to mention that despite roads being the primary mode of transportation, the aviation sector accounts for a large share of emissions and energy consumption worldwide. The ensuing upgrading of existing soils to improve the runway needs to be evaluated [35]. In the Czech Republic, for example, the evaluation of former pond systems is currently being developed at the Czech Technical College in Prague in collaboration with Palacky College in Olomouc. The assessment considers various technical and socioeconomic criteria to determine land use and avoid major incidents [36]. For example, a fire in the terminals of Canton Airport made the public aware of the fire hazard in crowded terminals. Authorities should thus implement stricter fire safety management to achieve sustainable aviation [37]. Due to these events, researchers and airport authorities are interested in sustainable airports that can reduce waste, protect natural resources, and provide natural stormwater management to improve sustainable airport quality. For example, case studies of sustainable airport development have been used to illustrate the feasibility of the proposed frameworks [38].

In short, airport pavement design and construction must meet rigorous requirements and higher safety standards. In this case, airport operators are increasingly adopting environmental management plans and green measures, which use construction techniques and innovative materials to achieve sustainability of airfield pavements [39] operated by local authorities [40]. Moreover, major infrastructure projects (MIPs) rapidly increase worldwide while providing a conceptual framework for managing value creation in a project provider organisation [41].

4.5. Building Comfort and Airport Materials

Passengers and employees of airports and airlines spend significant time in airport buildings. Optimal user comfort can be achieved by incorporating natural light and ad-

dressing the functional characteristics of air travel while conserving energy. Consequently, many airports worldwide are developing greener business profiles to reduce the environmental and socioeconomic impacts caused by airline operations, such as in the case of the LEED airport sustainability certification scheme [42].

More than 2500 airports worldwide thus represent critical infrastructure serving 4 billion passengers annually. Some propose a framework for assessing airports' sustainability and improving effective practices such as low-emission electricity procurement and gate facilities to help airports achieve sustainability goals [43]. Sustainability is becoming a priority for airport projects, as are pavement treatments with life-cycle cost analysis. Aviation infrastructure development is critical to economic and social growth [44].

Thus, the construction, maintenance, and rehabilitation cost of airport pavements is enormous. Some case studies illustrate the impact of economic evaluation on decision-making for projects where the use of crack-sealed pavements (CSOL) is 35.8% and 28.3% more cost-effective than Portland cement concrete (PCC) and hot mix asphalt (HMA), respectively [45], as well as the central role that local governments play in the impacts of infrastructure development on soil, water, air, and wildlife species, and the strategies for mitigating and adapting wildlife populations at airports [46]. In today's rapidly changing global economy, airports play an important role in measuring and managing sustainable performance based on economic, social, and environmental parameters [47].

Nevertheless, developed and less developed countries take different approaches to formulating strategic plans for aviation. These plans are often dictated by local political pressures and influenced by uncoordinated foreign aid, with private airports being more efficient than those with a mixed ownership/management model [48]. For example, a lawn mower reduces staffing requirements and local emissions. However, staff are still needed for inspections and maintenance [49]. At the same time, autonomous vehicles equipped with integrity enhancement systems can also potentially increase the safety, efficiency, and sustainability of airport operations on the ground [50].

In addition, some of the literature explores the impact of blockchain technology on operations management (OM) in supply chain management (SCM) and the links between blockchain technology, OM and sustainability aspects within SCM, looking at the airport industry from a sustainable performance perspective [51]. For instance, IBM's FoodTrust and Alibaba's Food Trust Frameworks are applying blockchain technology to the food cold chain via ocean and air transportation, reducing food losses and associated greenhouse gas emissions by 42.1% and 21.8%, respectively [52]. Airports worldwide are increasing their efforts to reduce the impact of aviation by implementing environmental management systems and certification schemes for their infrastructure and operations. Still, these only partially cover all the environmental impacts of aviation activities at an airport [53].

Some research proposes an automated ground handling management structure that uses information exchange with the airport's collaborative decision-making system to assign fully automated or semi-automated vehicles to ground handling tasks [54], in conjunction with airport safety and management issues, technical efficiency, and airport regulation [55]. Some studies also address how airport companies are meeting the 17 Sustainable Development Goals (SDGs) introduced by the United Nations in 2015. However, they are barely meeting these goals [56].

Finally, another stream of literature examines the quality of service (QoS) assessment process at airport terminals to find gaps, highlight trends, and discuss current challenges, such as the lack of applications [57]. Moreover, some considerations are given on how to manage the air cargo handling process qualitatively, with certain requirements, such as competent cargo staff, procedures, cargo information system, infrastructure with sufficient capacity, and process management, showing that the environmental and safety aspects of the process are of significant importance for sustainability [58], which is also in line with the balanced scorecard perspective, system sustainability, and safety requirements [59,60].

4.6. Energy Management

Airports use fossil fuels and electricity to meet various operational needs, including heating, ventilation, air conditioning (HVAC), and lighting. For instance, a best energy management practice is implementing an energy monitoring system. Literature posits that an airport's energy management practices indicate sustainability. However, implementation depends on site characteristics, including climate, occupancy levels, and hours of operation, and an index can help airport managers coordinate strategies for the sustainable development of energy, water, and environmental systems [13]. Also, the aviation industry is responsible for many emissions and energy consumption, such as upgrading existing soils through cement stabilisation [35].

On the other hand, on-site renewable energy is another typical indicator of sustainability discussed in the literature. Airports are ideal candidates for using on-site renewable energy, such as photovoltaic (PV) systems, which ideally meet both the airports and the community's electricity needs, also in terms of waste management, reducing waste per passenger and aircraft movement [61].

4.7. Air Quality and Water Management

Exposure to indoor air pollutants can negatively impact human health, including increased risk of respiratory disease, cardiovascular disease, and death. Indoor air quality research focuses on the pollutants and factors contributing to occupant exposure in facilities such as terminals and control towers [13]. Research on emissions from ground handling equipment, ground power units, and aircraft engines is more limited than research on aircraft emissions [35].

Conversely, airports consume water for indoor and outdoor operations. They can reduce water consumption by using water-efficient fixtures, reducing irrigation needs, and using alternative water sources. Rainwater harvesting, wastewater reclamation, greywater reuse, seawater reuse, and greywater reuse have already been explored [57]. As the world's population grows, pressure on finite water resources increases, especially in desert areas. Satellite measurements of land subsidence can serve as the basis for many aspects of sustainable water resource management plans that will need to be developed and implemented in the coming years [62].

4.8. Business

Some studies suggest that developing a public-private partnership business centre in the region, especially in the airport area, will improve regional economic equity. The results suggest a cooperative agreement between the local government and airport management benefits both parties [63]. For example, cooperation between Seville-San Pablo Airport and Seville public-private organisations has helped to improve the accessibility and brand image of Seville as a tourist destination and to control rising costs, optimise processes, reallocate resources, and especially improve access by air [64]. Also, the pandemic COVID -19 caused significant disruption to the airline industry, including the closure of flights in many markets [65].

Second, values are important in understanding managerial behaviour, as some studies identify the values that influence an organisation's business approach and determine managers' value hierarchy using factor analysis [66]. Some studies have applied ideas from organisational ecology to understand the economic strategies and socioeconomic incompatibilities between different business models [54]. On the other hand, methods to improve energy management in airports have been proposed, showing potential for energy savings [67].

Finally, concerning the economic evaluation of greenhouse gas savings and economic benefits associated with sustainable water and energy management, some airports have shown positive steps toward sustainability [68], some have shown a significant economic impact on the different environments studied [69], while airports link distant goals but do not prioritise environmental management issues [70].

Key points from Section 4 are depicted in Table 3.

Table 3. Summary table with an overview of the research findings. (Source: own elaboration).

Area	Methods
Airports	• Passenger surveys, sustainability performance, • Sustainability indicators according to GRI guidelines. • Airport efficiency and economic sustainability using the DEA (Data Envelopment Analysis) method
Sustainability and Sustainable Development	• Develop sustainable management plans, identify problems, and set performance targets. • Corporate social responsibility (CSR). • Balanced scorecard for sustainability. • Airport sustainability ranking index
Airline industry	• Systems approach and assessment tool for airport strategy. • Sustainability of new routes and forecast the economic impact on their catchment area. • A multi-criteria decision-making (MCDM) approach is used to identify key factors and rank them by their relative importance, revealing that financial factors. • New air traffic management and load measurement systems for operators to reduce environmental impacts
Construction	• Urban architecture, technology, neighbourhood management. • Highlight the complex interplay between ecological and built infrastructure. • Airports adopting environmental management plans and green measures.
Building Comfort and Airport Materials	• Developing greener business profiles to reduce the environmental and socioeconomic impacts. • LEED airport sustainability certification scheme. • Cost-effective of crack-sealed pavements (CSOL), cement concrete (PCC) and hot mix asphalt. • Impact of blockchain technology on: operations management (OM) in supply chain management (SCM) and the links between blockchain technology, OM and sustainability aspects within SCM
Energy Management	• Airport's energy management. • Using on-site renewable energy, such as photovoltaic (PV) systems
Air quality and water management	• Research on emissions from airport airside. • Sustainable water resource management.
Business	• Cooperation between airport and public-private organisations. • Socioeconomic incompatibilities between different business models. • Economic impact on the different environments studied.

5. Conclusions

A systematic review of 71 articles on airport sustainability was conducted, applying an existing framework for assessing airport and aviation sustainability. A systematic review of airport and aviation environmental sustainability research indicates that interest is steadily increasing, but more research is needed. Greenhouse gas emissions from energy use are among airport environmental sustainability research's most commonly used parameters. In the future, the increased use of assessment methods such as life cycle assessment (LCA) will help guide decision-makers and policy outcomes in a more robust, detailed direction. LCA can evaluate all components of an airport's construction and operations activities and decide which practices provide optimal results.

Future research should link environmental impacts to economic parameters for various airport stakeholders. The environmental sustainability of an airport is achieved by engaging various economic stakeholders. Therefore, this is done by providing electricity from renewable, low-carbon sources and electrifying all ground handling equipment and vehicles within the boundaries of the airport system. These proposed sustainability practices can result in immediate environmental benefits without major concessions. In addition, they are considered achievable in the short term. Airports should systematically consider all relevant environmental sustainability indicators and link environmental impacts to on-site ecosystem impacts. Therefore, this will help airports and the aviation industry address the major global challenges. Future studies also could consider the development of frameworks that take into account the interaction between the three pillars of sustainability and the trade-offs between them. On the other hand, conducting longitudinal studies to observe the evolution of businesses in the airport sector, as well as comparative studies in some regions of the world, would be interesting. This would allow the construction of indicators and frameworks for business practices, challenges, and sustainability.

In terms of limitations the analyzed studies is predominantly confined to specific regions, and their overall quantity remains relatively limited. This circumstance has the potential to introduce a constraint to the generalizability of observations on a global scale. Conversely, the investigations encompass a diverse array of methodologies, encompassing both quantitative and qualitative approaches. This diversity presents challenges in facilitating direct comparisons between studies and engendering the formulation of a universally applicable framework.

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