

The Take-Off of Sustainability: Evaluating Sustainable Airport Performance

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ABSTRACT

The aviation industry plays a vital role in our interconnected world. However, its growth also comes with environmental concerns. Airports, as air travel hubs embrace sustainability. This is to minimize their ecological impact. This effort involves looking beyond airplanes at the entire airport ecosystem. It includes energy use. Waste management and noise pollution are also considered. The discussion will explore sustainable airport performance. It will examine how airports measure their sustainability efforts. It focuses on improvement and the benefits of sustainable commitment in airport operations. Drawing from relevant literature, this study enhances existing work. The study encourages future research by identifying priority areas regarding sustainable airport commitment and contributing to sustainable airport performance.

KEYWORDS sustainable airport commitment, sustainable airport performance, airport research, systematic literature review, airport research



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INTRODUCTION

Committing to sustainability is crucial for airports to achieve long-term sustainable performance. Airports as places for travel and trade play a vital role in global transportation and economic development. However, addressing the significant environmental, social, and economic impacts caused by airport operations is important to ensure sustainability.

This study examines the establishment of a sustainable commitment for airports and how it affects their overall performance. To better understand this, we refer to relevant literature. Airports contribute greatly to environmental degradation through carbon emissions, noise pollution, and waste generation. According to a study by the International Civil Aviation Organization (ICAO), the aviation industry is responsible for roughly 2% of global carbon emissions (ICAO, 2019).

Developing mitigation methods for these environmental problems is necessary to build a sustainable airport strategy. The literature suggests that implementing energy-efficient technologies, such as renewable energy sources, efficient lighting, and advanced building management systems, can significantly reduce an airport's carbon footprint (Chati & Balakrishnan, 2018). Furthermore, encouraging environmentally friendly modes of transportation such as electric cars and well-functioning public transit systems can contribute to the reduction of emissions even further (Janić, 2019).

Airports significantly impact local communities, including noise pollution, air quality issues, and land use concerns. A sustainable airport commitment must address these social impacts to ensure the well-being of neighboring communities. Research highlights the importance of implementing noise abatement measures, such as noise monitoring systems and flight path optimization, to minimize the impact of aircraft noise on residential areas (Wu et al., 2024). Additionally, engaging with local communities through public consultations and

community outreach programs can foster trust and address concerns (Ambrosio-Albala et al., 2023).

Previous studies have focused on various industries' drivers and barriers to sustainable performance. However, the literature on sustainable airport commitment as a trigger for sustainable airport performance has not been well explored. Thus, this article maps out the main research topics at the intersection of sustainable airport commitment and sustainability-oriented airport performance (Figure 1). The combined bibliography was used to identify the main lines of research in the literature on sustainable airport commitment and sustainability-oriented airport performance in a broad scope and to suggest topics for future research.



Figure 1. Sustainable airport commitment for sustainable airport performance

METHOD

A systematic literature review is a research design used to systematically synthesize existing research evidence in terms of searching research articles, critical reviews, and synthesis of research results to answer trending topics (Talwar et al., 2021a). Systematic literature reviews are research designs that enable robust investigation into the state of the art from a particular research field (Dhir et al., 2020), systematic synthesis of evidence, and critical appraisals, while recognizing research gaps to promote future inquiry and knowledge advancement (Kraus et al., 2022). This study adopts the systematic literature review approach used by recent studies to holistically assess and synthesize the progress of the current relevant literature on sustainable airport commitment and sustainable airport performance.

Identifying studies and research questions is the first step in conducting a systematic literature review. Finding relevant studies is the next step. After finding relevant studies, the next step is to evaluate them critically. Finally, the results should be presented and discussed. Information is then gathered and retrieved in the third and fourth stages. The fourth stage involves synthesizing the results and drawing conclusions. The fifth and final stage is to interpret the results and draw conclusions. Finally, the data are synthesized and reported. This study also involved a review panel consisting of two professors and a researcher, establishing the conceptual boundaries of this topic.

Consultations were held at every level, from the initial identification to the final selection of relevant studies. The criteria for determining pertinent studies of this systematic literature review included the research question's relevance, the study design's quality and rigor, the currency of the publication, and the alignment with the conceptual boundaries established by the review panel. These criteria ensured that only studies that met the necessary standards and contributed to the overall objectives of the review were included in the data synthesis. In the course of this consultation, differences of opinion among the authors were resolved, and a consensus was reached to carry out the study. We followed established protocols to ensure the replication and accuracy of our findings (Talwar et al., 2021b).

Figure 2 presents the research protocols from the initial data collection process to the determination of the number of key articles, which were then researched to achieve the research objectives.

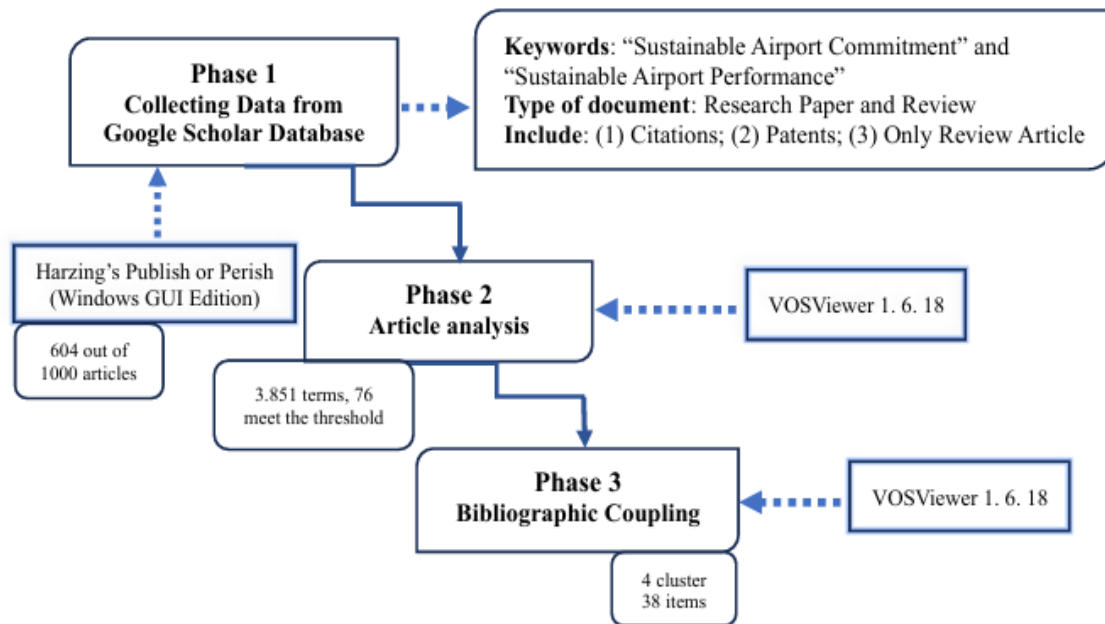


Figure 2. Research protocols of the systematic literature review

RESULT AND DISCUSSION

Descriptive Analysis

Figure 2 presents information about sustainable airport commitment and performance in the last ten years. The topic began to be published in 2014 and then began to increase from year to year. There was especially a spike in publications in 2023 which doubled compared to 2020, increased sharply in 2020 and 2021, and declined until this data was taken in mid-2024. This indicates that sustainable airport commitment is considered the research trend and has become the agenda of researchers to maintain sustainable airport performance.

The selected 604 articles were published in several sources (Figure 4) including the following: Elsevier (212- 35%), mdpi.com (123-29%), Springer (83-14%), Emerald (33-5%), Taylor & Francis (35-6%), Wiley online library (22-4%), Frontiersin.org (11-2%), journals.sagepub.com (11-2%), taylorfrancis.com (15-2%), search.proquest.com (8-1%), and journal.ekb.eg (1-0%). This provides information that this topic has become a trend in sustainability efforts.

Figures 3 and 4 show the increasing research on sustainable airport commitment as an alternative strategy to increase airport performance and maintain sustainability. Maintaining sustainability and environmental preservation presents opportunities and challenges for every country, industry, and business entity. All stakeholders are involved in implementing sustainable commitment. First, governments and countries commit to green subsidies to increase sustainable practices (Dong et al., 2021). As the major way that the government can influence the control of industrial pollution, policies are considered an “invisible hand” (Dong & Liu, 2020). Second, business managers must increase their commitment to the environment and build a culture of action for sustainable development (Roscoe et al., 2019); ((Kraus et al., 2020). Third, there is a standard operating procedure for environmental ethics guidance (Singh et al., 2019). Thus, these publications illustrate an increasing commitment to sustainable performance, possible research gaps in the airport context, and insight into related areas.

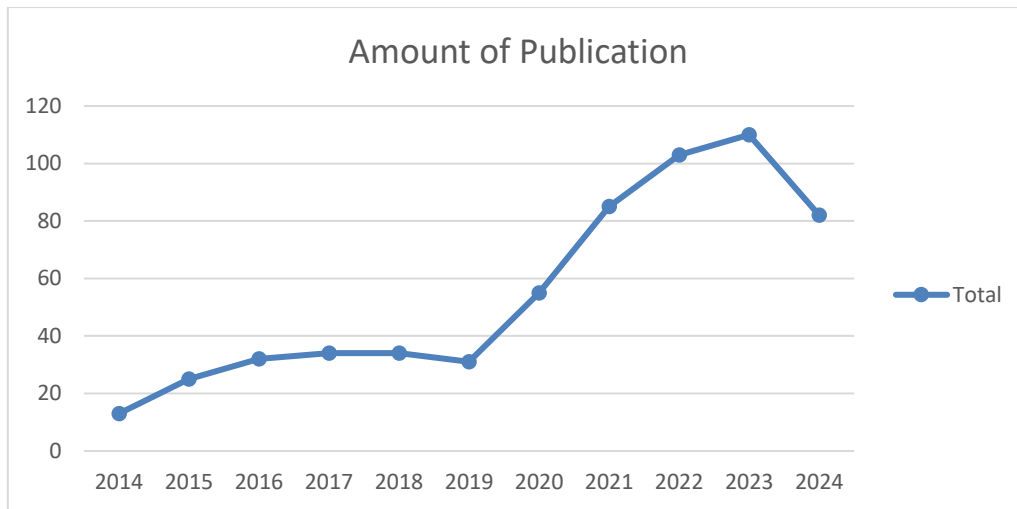


Figure 3. Annual growth in the number of publications

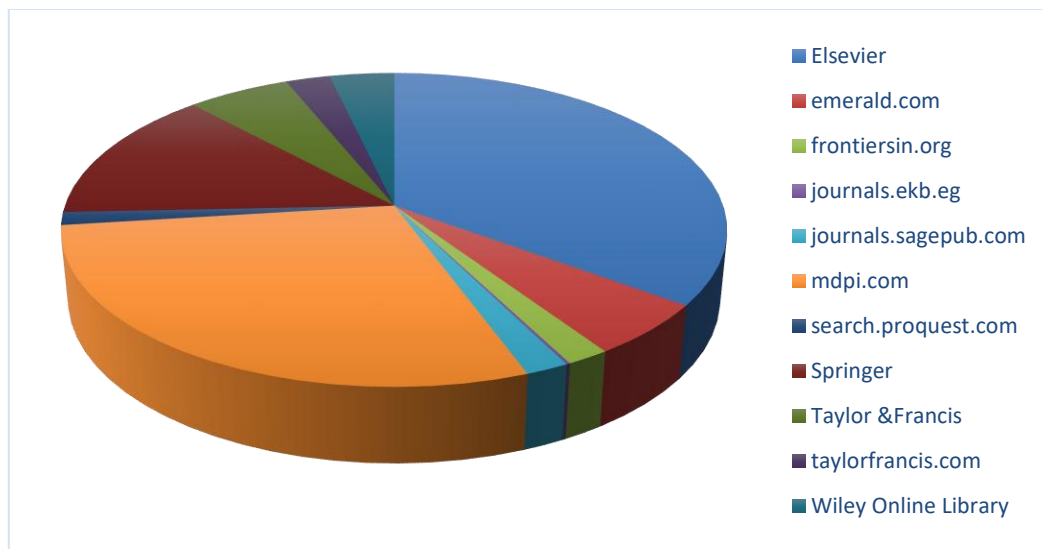


Figure 4. Percentage of article publications in published

Bibliographic Analysis

VOS Viewer 1.6.18 software was used to combine the bibliographies of these documents to identify the main research themes in sustainable airport commitment and performance. All articles were analyzed by linking a minimum of three articles per cluster. The cluster network is shown in detail in Figure 5. The results of the network visualization show that there were four main clusters related to the two research topics. Some of the relevant items in each cluster are described as follows.

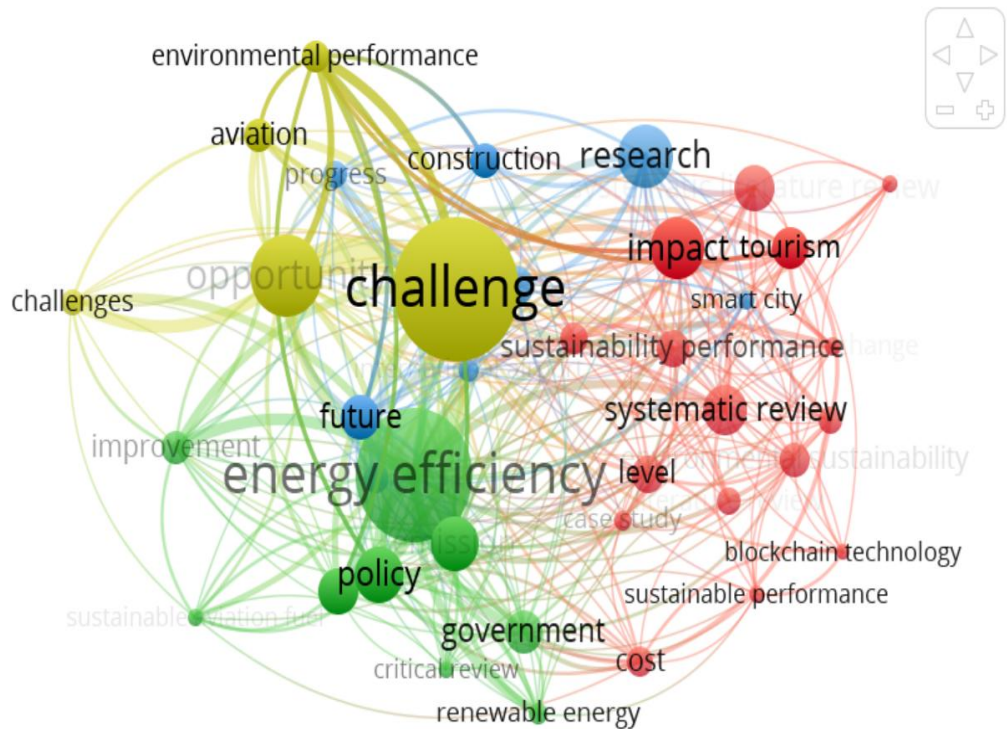


Figure 5. Network visualization of sustainable airport commitment and sustainable airport performance

Cluster 1 (Strategic Adoption for Sustainable Commitment)

The airport industry has increasingly recognized the importance of sustainability in recent years, driven by environmental concerns and regulatory pressures. Strategic adoption of sustainable practices has become crucial for long-term viability and stakeholder satisfaction. From the ecological aspect, the airports are facing challenges such as reducing the gas of greenhouse gas (GHG) emissions and striving to create a zero-carbon environment, while often dealing with insufficient funding and a shortage of human resources. Hence, to achieve sustainability efficiently, airports need to set both strategical and tactical goals for sustainability, set performance indicators to those goals, construct lean in all processes to remove wastes, and improve efficiency, thus achieving the sustainability goals (Carlucci et al., 2018)

Several studies have been conducted within this cluster emphasizing the need to mobilize long-term commitments from stakeholders to improve sustainable performance through collaboration. To build this agenda, blockchain technologies, and sustainable development are needed. Blockchain technology can improve supply chain accountability and transparency by recording all transactions and changes irreversibly and permanently, enabling all parties to track a product's origin and journey and ensuring that it complies with sustainability standards (Saber et al., 2019). Moreover, sustainable development is necessary for the well-being of society, and it can be achieved when humanity can meet its present needs without affecting the ability of the people in the future to meet their own needs (Halişçelik & Soytaş, 2019); (Kutty et al., 2020).

Energy efficiency remains a key focus, with many airports investing in renewable energy sources. Munich Airport's adoption of photovoltaic systems and LED lighting has significantly reduced its carbon emissions (Budd, L., & Ison, 2020). Implementing such initiatives reduces operational costs and improves the airport's reputation among environmentally conscious travelers. However, challenges persist in balancing economic viability with environmental goals. The strategic adoption of sustainable

practices in the airport industry is no longer optional but necessary for future-proofing operations and meeting stakeholder expectations.

Cluster 2 (Factors Affecting Sustainable Commitment)

Research strongly suggests the government facilitate organizations in the adoption of green practices and commitment that can resultantly contribute to Sustainable Development Goals (SDGs) that have become one of the most important goals across the globe due to their significant role in economic prosperity and human well-being (Haque & Ntim, 2018); (Ilyas et al., 2020). Airports are under increasing pressure to mitigate the environmental impact of their operations, such as noise, air pollution, and greenhouse gas emissions (Upham & Mills, 2005).

The extant literature also suggests that adopting sustainable practices in the aviation industry is influenced by various institutional factors, including regulatory pressures, stakeholder demands, and industry norms (Kılıç et al., 2019). For example, a sustainable energy transition leads to regional developments that can mitigate risks, encourage green growth, and minimize the effects of industrialization. On the other hand, the development of information technology allows the government to build smart cities to improve the sustainable energy transition (Fratini et al., 2019), circular economy, and climate change mitigation toward sustainability (Khan et al., 2021).

One of the primary factors affecting sustainable commitment in the airport industry is government regulation and policy. Governments worldwide have implemented various policies and regulations intended to reduce the environmental impact of airports, such as emissions reduction targets, energy efficiency standards, and waste management requirements (Budd et al., 2013). Airports that fail to comply with these regulations risk facing fines, legal penalties, or even the loss of operating licenses.

Another important factor to consider is the influence of stakeholders and public perception. Airports are under increasing scrutiny from environmental organizations, local communities, and the public regarding their sustainability efforts. Airports seen as environmentally irresponsible may suffer from damage to their reputation, decreased passenger numbers, and difficulty obtaining funding or support for future development projects. (Budd & Ison, 2022). As a result, many airports are proactively adopting sustainable practices to improve their public image and maintain stakeholder support.

Cluster 3 (Research on Future International Airport)

One important area of study has been evaluating the sustainability performance of existing airports. Studies have utilized frameworks such as the Airport Carbon Accreditation (ACA) program and the Global Reporting Initiative (GRI) to evaluate airports' carbon emissions, energy efficiency, waste management, and other sustainability metrics (Huderek-Glapska & Nowak, 2016). These assessments have provided valuable insights into the current sustainability challenges and best practices within the airport industry (Lim et al., 2018).

Building on this foundation, researchers have also investigated strategies and technologies for improving the sustainability performance of future international airports. One prominent area of focus is the adoption of renewable energy sources, such as solar, wind, and geothermal power, to reduce airports' reliance on fossil fuels and carbon emissions (Kucukvar et al., 2019). Researchers have also explored the potential of sustainable airport design, including the use of energy-efficient building materials, water conservation systems, and waste-to-energy solutions (Li et al., 2021).

Another important aspect of future airport sustainability is integrating multimodal transportation systems. Researchers have studied the potential for airports to serve as hubs for seamless connections between air travel, public transportation, and other modes of sustainable mobility, such as electric vehicles and high-speed rail (Alkaabi, 2011). This approach can help reduce the environmental

impact of airport-related ground transportation and improve overall accessibility for passengers and employees.

Furthermore, researchers have investigated the role of stakeholder engagement and collaborative decision-making in shaping the sustainability of future international airports. Studies have highlighted the importance of involving local communities, environmental organizations, and other stakeholders in the planning and development of airports to address their concerns and incorporate sustainable practices (Budd, L., & Ison, 2020).

Overall, the research on future international airports' sustainability performance has revealed the multifaceted nature of this challenge and the need for a holistic approach that considers environmental, social, and economic factors. The aviation industry can work towards a more sustainable and adaptable future by utilizing advanced technologies, establishing regulatory frameworks, and actively engaging stakeholders.

Cluster 4 (Environmental Performance Challenge in Aviation)

The sustainable development goals (SDGs), announced by the UN, consist of three main pillars. These are economic, social, and environmental (Allison et al., 2013). Airports are encountering critical challenges in accomplishing the SDGs. From the environmental aspect, the airports are facing challenges such as reducing the gas of greenhouse gas (GHG) emissions and striving to create a zero-carbon environment, while often dealing with insufficient funding and a shortage of human resources.

Lee et al. (2020) quantified the aviation sector's contribution to global carbon emissions. They estimate that it accounts for about 3.5% of the total anthropogenic climate impact, including CO₂ and non-CO₂ effects such as contrails (Lee et al., 2021). Additionally, Basner et al. (2017) provide empirical evidence on the health impacts of aircraft noise, showing significant associations between noise exposure and cardiovascular diseases, sleep disturbances, and cognitive impairment in children (Basner et al., 2017). Furthermore, a study by Rutherford and Zeinali (2019) on fuel efficiency found that airlines adopting more fuel-efficient aircraft reduced their emissions intensity by 2-3% annually, demonstrating the potential of technological advancements in mitigating environmental impact (Sola Zheng et al., 2021).

The environmental performance challenges in aviation are significant and multifaceted, involving emissions, noise pollution, waste management, and local environmental impacts. While the industry has made strides in addressing these issues through regulatory frameworks, technological advancements, and innovative fuels, much work remains to be done. Achieving a more sustainable aviation sector will require continued collaboration between governments, industry stakeholders, and environmental organizations. Moreover, there should be enhanced investment in cleaner technologies and sustainable practices.

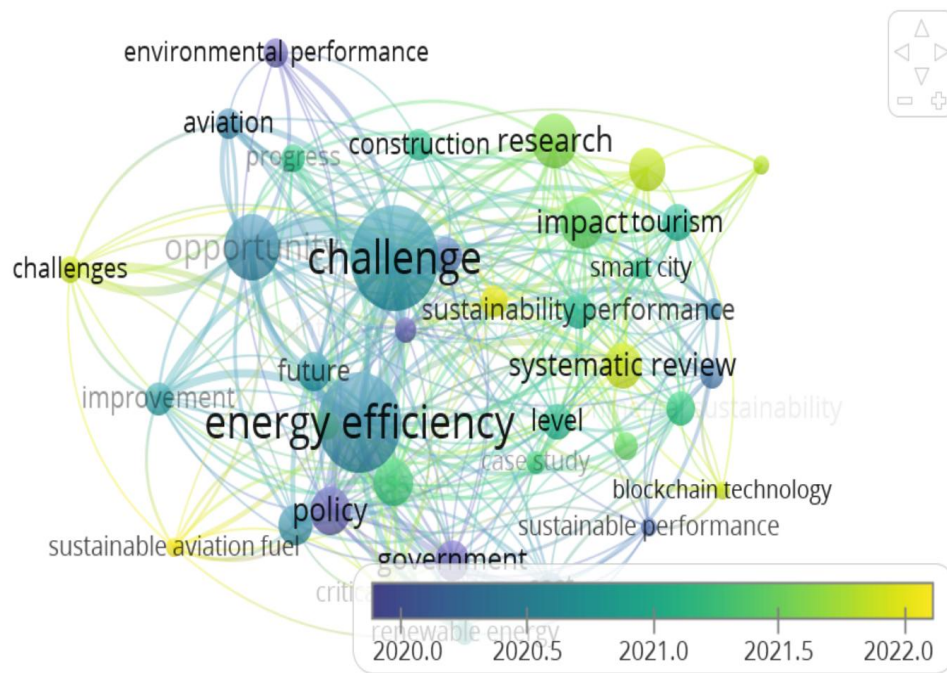


Figure 6. Overlay visualization of sustainable airport commitment and sustainable airport performance

Upon further analysis, we have assessed the research on sustainable airport commitment and performance over the past three years (Figure 6). The results show that at the beginning of 2020, sustainable airport commitment and performance were mostly related to environmental performance, sustainability performance, policy, and government. After mid-2020, the most relevant topics are energy efficiency and challenge, followed by opportunity, improvement, and aviation. In early 2021, the essential issues included construction, research, and impact tourism, closely followed by smart city and sustainable performance.

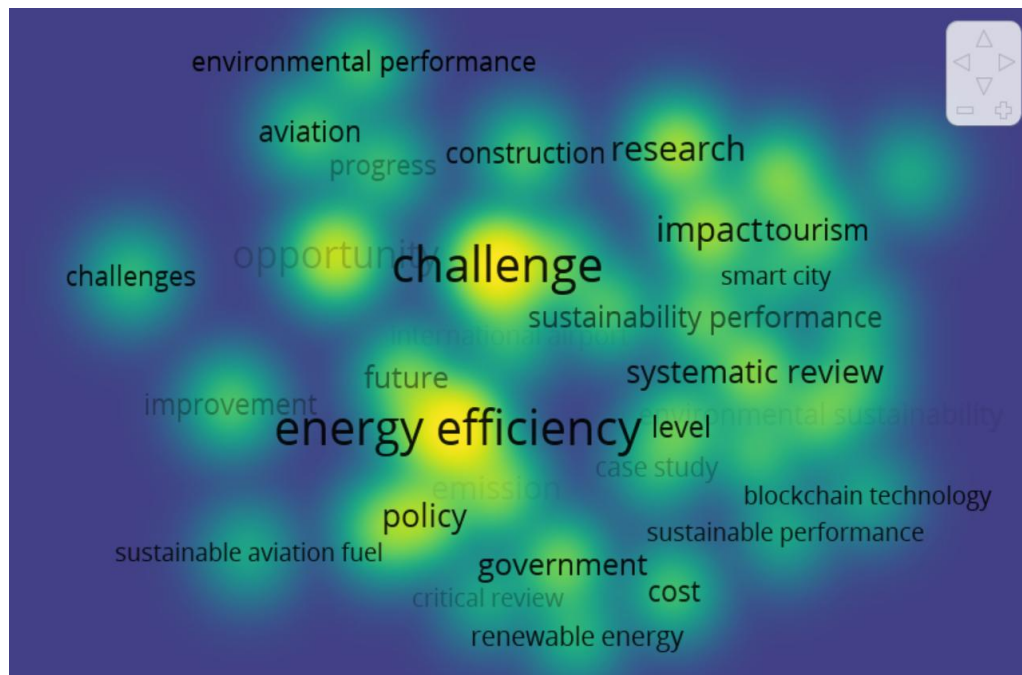


Figure 7. Density visualization of sustainable airport commitment and sustainable airport performance

Discussion

The study provides a systematic literature review focused on the intersection of sustainable airport commitments and airport performance. Research in this area has gained prominence since 2014, showing a steady increase, with a particular surge in 2023. This suggests a growing recognition of the importance of sustainability in the aviation industry. The review highlights the roles of governments, businesses, and environmental ethics in promoting sustainability. For instance, the government's role in providing green subsidies and setting regulatory frameworks serves as an "invisible hand" in industrial pollution control (Dong et al., 2021) and (Dong & Liu, 2020).

The bibliometric analysis shows a multidisciplinary approach to achieving sustainable airport performance. Key findings indicate that airports' sustainability commitments are evaluated through diverse methodologies, including network efficiency models, balanced scorecards, and ranking indices. These approaches focus on operational efficiency, financial performance, and sustainability practices. Efforts to achieve sustainable airport performance include efficient use of resources, transparency in sustainability reporting, and adopting green practices. However, challenges persist, such as integrating various sustainability dimensions into a coherent framework that addresses the complex interactions between operational, economic, environmental, and social aspects. The analysis also points to the importance of stakeholder involvement, regulatory support, and technological adoption in driving sustainable airport initiatives. Furthermore, airports' performance is linked to local economic development, emphasizing the broader socio-economic impact of sustainable practices.

The previous research primarily focused on increasing business managers' commitment to environmental responsibility (Roscoe et al., 2019); (Kraus et al., 2022). This is similar to current discussions about increasing environmental awareness within corporate strategies. However, recent studies emphasize the need for broader stakeholder involvement, including governments and industry leaders, to ensure long-term sustainability.

When comparing the current literature to previous studies, the increasing emphasis on bibliometric analysis and the integration of circular economy principles marks a shift towards a more data-driven and holistic approach to sustainability. The gap identified in this domain relates to the under-explored area of how smaller airports or regions outside the most developed economies are implementing or struggling to implement sustainable practices.

Furthermore, while much attention has been given to larger infrastructure projects, there is limited research on community engagement and the social impact of sustainability initiatives in aviation. Thus, future research could explore how smaller airports and developing countries can overcome barriers to sustainability, along with a deeper dive into the socio-economic impacts of green innovations on communities surrounding airports. Additionally, more work is needed to quantify the long-term performance benefits of these sustainable commitments in operational metrics beyond environmental factors.

Considerations and Research's Future Line

Future research in sustainable airport development can greatly benefit from focusing on several key areas. One promising avenue is the **quantification of sustainability impact**, where more robust methodologies are needed to measure and compare the effectiveness of various sustainability initiatives. This could involve refining current metrics or creating new indices to assess these efforts' environmental, social, and economic impacts. Additionally, **innovative financing models** such as green bonds and public-private partnerships offer exciting potential for securing the necessary funding for sustainable infrastructure. Research in this area could investigate how to balance the initial expenses of green investments with the long-term advantages, ensuring that airports can achieve sustainability goals without jeopardizing financial stability.

Another critical area is **behavioral change**, focusing on how airports can encourage more sustainable actions from passengers, employees, and other stakeholders. This may involve researching incentive programs, awareness campaigns, and nudging techniques to promote behaviors such as energy conservation and waste reduction. Resilience and adaptation research are crucial for helping airports prepare for the impacts of climate change, including extreme weather events while maintaining their sustainability commitments. Lastly, **technology integration** offers a fertile ground for exploration, with emerging innovations such as AI, automation, and renewable energy systems presenting new opportunities to enhance airport operations' efficiency and reduce their environmental footprint. Together, these areas form a comprehensive roadmap for advancing the sustainability and resilience of the aviation industry.

CONCLUSION

The systematic literature review uncovers several central themes and insights into sustainable airport commitment and performance, shedding light on both the advancements and ongoing challenges in the aviation sector's sustainability efforts. One prominent theme is the integration of sustainability frameworks into airport operations, where airports are increasingly responding to regulatory and normative pressures to adopt sustainability practices. Frameworks such as the Airport Carbon Accreditation (ACA) exemplify the industry's movement toward standardizing sustainability across operations. Another significant theme is technological innovation, which is key to enhancing sustainable performance. Technologies related to energy efficiency, sustainable building designs, waste management, and noise reduction are helping airports transition to more sustainable models, though challenges in terms of cost and scalability remain.

In addition, stakeholder engagement is critical for successful sustainability initiatives, as airports rely on the support of the community, regulators, employees, and passengers to maintain their social license to operate. The review also highlights the difficulty of balancing economic viability with sustainability goals, particularly in the face of infrastructure costs and long-term planning. Despite this, green financing and sustainable business models are becoming increasingly important in maintaining economic performance while pursuing environmental and social objectives. Finally, policy implications play a crucial role in the sustainable performance of airports. Governance structures and regulatory frameworks significantly shape sustainability practices. The trend toward more stringent environmental regulations, especially around emissions reduction, suggests that policy will continue to drive innovation and commitment to airport sustainability.

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