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RESEARCH ARTICLE

Transformation Towards Sustainable Airports: A Review of Policies and Challenges in Indonesia

Suhanto [1*)], Sukarwoto [1)], Moch. Rifai [1)], Irfan [1)], Yuyun Suprapto [2)], Hadi Prayitno [2)]

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Abstract

The rapid growth of the aviation industry also presents significant challenges regarding environmental impact. In Indonesia, airports are facing pressure to reduce their carbon footprint and improve overall sustainability. This research aims to provide a clear picture of the policies and challenges of implementing sustainable airports in Indonesia. A systematic literature review was carried out using PRISMA guidelines, which aims to analyze knowledge regarding sustainability at airports. This research uses the Google Scholar database, Scopus from Elsevier, the Web of Science database from Clarivate, and the 2023 PT Angkasa Pura I and II sustainability reports. The results of the research show that sustainable airport policies focus on developing environmentally friendly airports by prioritizing environmental management and collaborating with various stakeholders. Environmentally sustainable airports have been implemented, but they are limited to large airports in Indonesia.

Keyword: airport, sustainable, SLR, eco-friendly

Introduction

Airports, as vital infrastructure in the modern transportation system, play an important role in economic growth and global connectivity (Cheung et al., 2020). However, the rapid growth of the aviation industry also presents significant challenges regarding environmental impacts (Miller et al., 2023). In Indonesia, airports are facing pressure to reduce their carbon footprint and improve overall sustainability (Fiona Greer, 2020).

The transformation towards sustainability at these airports is becoming increasingly important, not only as a response to global environmental demands but also as a commitment to building sustainable and environmentally friendly infrastructure (Dimitriou & Karagkouni, 2022). Various policies and practices have been implemented at airports around the world (Bamidele et al., 2023), but the unique challenges in Indonesia demand approaches that are adapted to local conditions.

This literature study aims to investigate various sustainable policies and practices implemented at airports in Indonesia. The data source in this research was also obtained from the 2023 Sustainability Report by PT. Persero Angkasa Pura I and II are state-owned companies in the field of airport services in Indonesia. Drawing on international and local studies, this article outlines the framework needed to understand the sustainability transformation of the sector. In addition, this article also identifies specific challenges faced in implementing these policies, as well as potential solutions that can be adopted to achieve sustainability goals.

The main objectives of this research are: 1) to provide an overview of environmental sustainability aspects in the airport context. 2) To examine the sustainable practices carried out by major airport operators in the world. 3) To study the relationship between sustainable practices at airports and sustainable development goals.

[1]Politeknik Penerbangan Makassar, [2]Politeknik Penerbangan Surabaya

*) corresponding author

Suhanto

Email: suhanto@poltekbangmakassar.ac.id

Method

The main objectives of this research are: 1) to provide an overview of environmental sustainability aspects in the airport context. 2) To examine the sustainable practices carried out by major airport operators in the world. 3) To study the relationship between sustainable practices at airports and sustainable development goals.

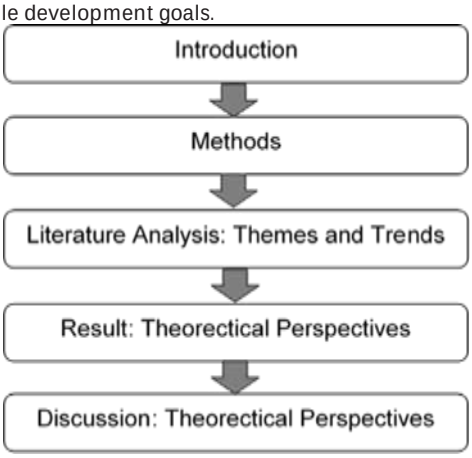

Figure 1. Research Design

The selection of reference papers consists of four stages: (1) selection of relevant databases, (2) extracting papers, (3) screening abstracts, and (4) screening full-text articles. The selection process is described using the PRISMA flow diagram. This research uses the Google Scholar database, Scopus from Elsevier, and the Web of Science database from Clarivate.

The research methodology begins by searching for articles with the keyword "Indonesia airport sustainability" in the abstract, combining with the boolean term "OR" and the keyword "sustainable airport policy in Indonesia," and then combining the boolean "OR" with the keyword "sustainable airport challenges in Indonesia."

The search results contained 200 articles from Google Scholar and 10 articles from the Scopus database, while nine articles were found in the Web of Science database. Only papers written in English were selected for further analysis in Figure 2

From the results of article selection, starting from the title and abstract screening process, complete articles based on include and exclude categories resulted in 26 journal articles for further discussion. Apart from reviewing the 26 journals, researchers also took data from the annual reports of the companies PT Angkas Pura I and II regarding sustainability in 2023 (Ignatov & Rudolf, 2023).

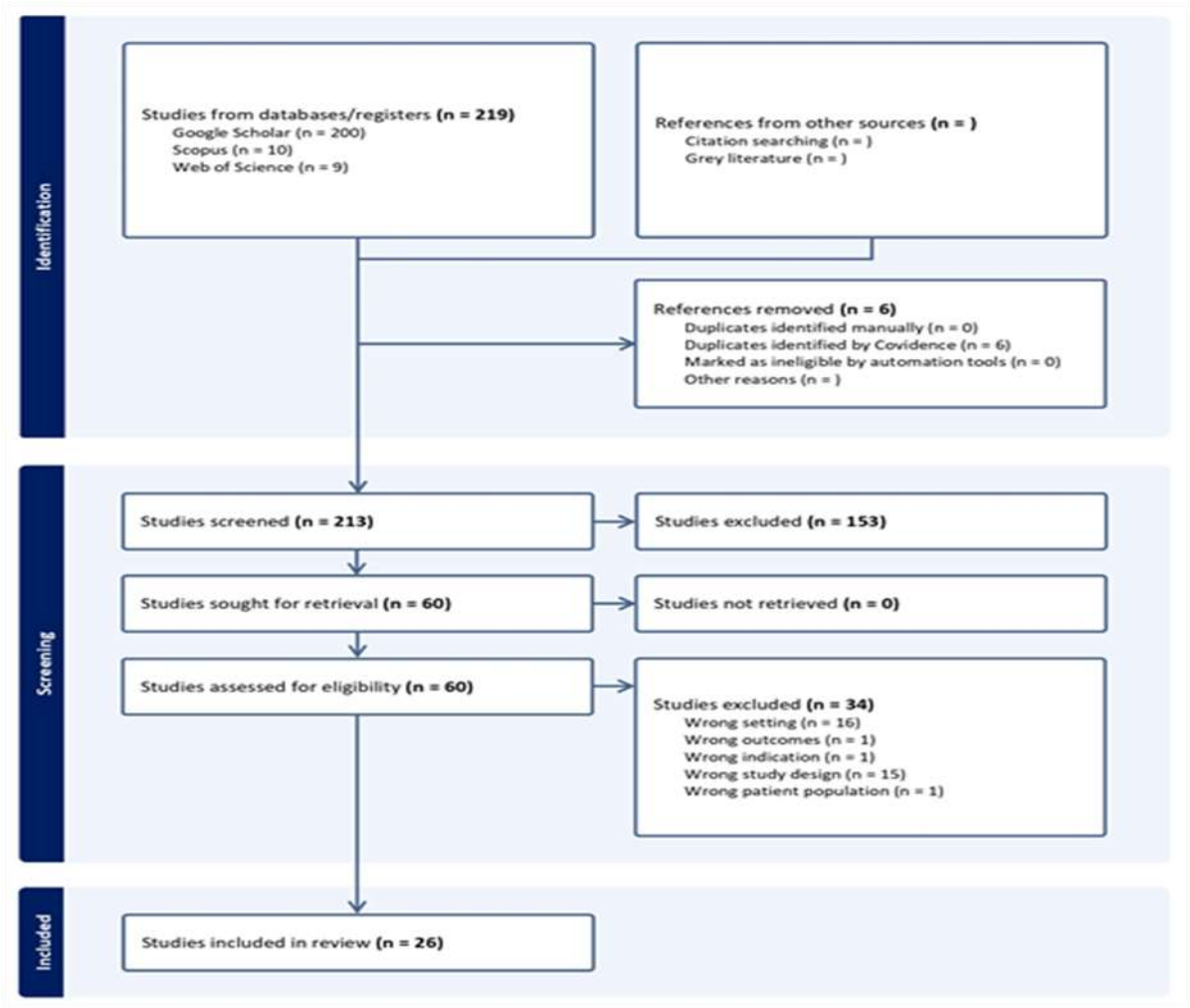

Figure 2. PRISMA Flow Diagram

Results and Discussion

Literature analysis: themes and trends

In recent years, the number of research publications has increased; from 2015 to 2024, there were 190 publications. Since 2019, interest in publications related to sustainability at airports has increased, as in Figure 3.

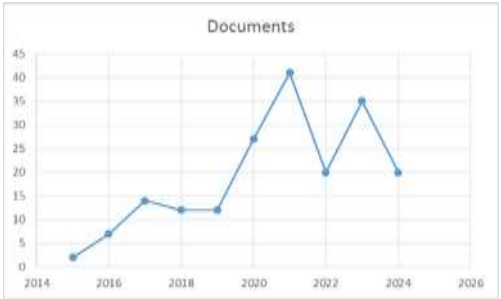

Figure 3. Number of Articles by Year

Results: theoretical perspective of policy analysis

Renewable energy policies at Indonesian airports are an important aspect of the country's commitment to reducing greenhouse gas emissions and promoting sustainable aviation. The Indonesian government, in collaboration with various stakeholders, has initiated measures such as the use of bio-jet fuel blending, signed agreements with international organizations such as ICAO and the United States for alternative sustainable aviation fuels, and established task forces such as ABRETF to promote the use of sustainable alternative fuels and renewable energy at airports. These efforts are in line with Indonesia's National Action Plan to reduce Greenhouse Gas emissions and demonstrate a proactive approach to reducing the environmental impact of aviation operations. Additionally, the focus on renewable energy is in line with Indonesia's broader goals to reduce emissions in the transportation sector and promote energy efficiency and conservation (Djajaputra et al., 2017).

Waste management and recycling programs at Indonesian airports, especially Soekarno-Hatta Airport, are very important for environmental sustainability and operational efficiency. Airport management in Indonesia is focused on implementing sustainable waste management practices, including waste reduction and waste processing initiatives (Rizaldy et al., 2018). In addition, the airport's commitment to the Eco-Airport

concept aims to transform it into an environmentally friendly facility, with a focus on waste separation, environmental conservation, and community involvement (Piao et al., 2021). Additionally, the handling of hazardous waste at airports is a major area of concern, requiring proper management and technical instructions for handling waste and chemicals to ensure safety and regulatory compliance. Overall, waste management and recycling programs play an important role in improving the environmental performance and sustainability of Indonesian airports.

Energy efficiency in buildings can be significantly improved through the use of LED lighting technology and energy-efficient HVAC systems (Sadewa, 2017). LED lighting offers high efficiency and can be combined with daylight harvest control systems to optimize the use of natural light, reducing the need for artificial lighting. On the other hand, energy-efficient HVAC systems play an important role in maintaining thermal comfort while minimizing energy consumption.

By optimizing energy performance with high-efficiency motors, pumps, and equipment and using automation for lighting and ventilation controls, buildings can achieve substantial energy savings. The integration of renewable energy sources further contributes to overall energy efficiency, aligning with the goal of achieving a Green Building Leadership in Energy and Environmental Design (LEED) rating.

Sustainable airport policies include a variety of initiatives aimed at reducing the environmental impact of aviation operations. Angkasa Pura II focuses on developing environmentally friendly airports by prioritizing environmental management, training employees on sustainability aspects, and collaborating with various stakeholders (PT Angkasa Pura I, 2023). The policy includes measures such as preventing pollution, implementing green processes, and engaging with local communities to protect ecosystems, all while emphasizing the importance of personnel understanding and implementing these environmental policies effectively (Tjahjono et al., 2023).

Implementation Challenges

Financial and technical barriers to implementing sustainable technologies in the aviation industry include the substantial financial investment required for the adoption of renewable energy, barriers due to limited green buildings, and noise pollution from dense air traffic (Waris et al., 2024). In addition, challenges in building digital and sustainable transformation in Indonesia's air transportation system stem from a variety of inefficient data center infrastructure, scattered digital services, and cyber attacks, which require secure and standardized infrastructure and integrated applications. In addition, the legal and political paradigm in Indonesia creates difficulties in achieving sustainability goals due to changes in regulations for political and economic interests, impacting environmental law enforcement and sustainable development initiatives (Priyanta & Zulkarnain, 2023). These barriers highlight the need for strategic planning, stakeholder collaboration, and regulatory compliance to overcome financial and technical barriers to implementing sustainable technologies in the aviation sector. Financial constraints are a significant barrier, as highlighted in a study on sustainable practices in the Indonesian construction industry, where lack of financial resources was identified as one of the main barriers to sustainable construction practices (Fitriani & Ajayi, 2023).

Lack of awareness and support from stakeholders can hinder the progress of sustainable development initiatives, especially in industries such as renewable energy (Arkantryo et al., 2023). Stakeholders play an important role in influencing policies and practices within organizations, impacting their sustainability efforts.

In the context of the renewable energy industry in Indonesia, the involvement of stakeholders is very important to achieve the ambitious targets set by the National Energy Policy, such as increasing the use of renewable energy to 23% in 2025 and 31% in 2050. However, without adequate awareness and support from stakeholders, including government agencies, investors, and society, the renewable energy sector may face challenges in meeting these targets and ensuring environmental sustainability. Therefore, raising awareness and gathering support from all stakeholders is essential to drive the transition towards a more sustainable energy landscape.

Regulatory and bureaucratic obstacles in implementing new policies can hinder the success of the public policy process, especially in waste management at airports. Collaboration between Indonesia and the UK highlights the importance of structured policies and sustainable development approaches to overcome obstacles such as competing priorities, inadequate policies, and the impact of COVID-19. The effectiveness of the law in Indonesia depends on law enforcement, facilities, infrastructure, and public legal culture, with challenges arising from spatial planning considerations and the need for infrastructure development in the midst of community settlements. To address global aviation priorities, a strategic policy implementation approach involving stakeholder cooperation, compliance with legislation, and commitment to planning and evaluation is essential to meet safety, capacity, efficiency, economic, and environmental goals (Hadi Prayitno et al., 2024).

Comparative Study

This research divides five categories of sustainability at airports, namely: 1) Energy and Atmosphere (energy management, renewable energy, energy-related emissions), 2) Comfort and Health (indoor air quality, ambient air quality, building occupant comfort), 3) Water and Wastewater (water conservation, water quality), 4) Materials and Resources (airfield materials, building materials, waste management), 5) Location and Habitat (habitat, transportation, resilience). This category comprehensively maps sustainability at airports [6]. This section explains the implementation of environmental sustainability at airports in Indonesia and other airports in the world.

Energy and Atmospheric Applications

Use of LED lights on taxiway lights in Soekarno Hatta, solar energy source from PLTS at Banyuwangi Airport, Soekarno Hatta, Ahmad Yani Semarang, I Gusti Ngurah Rai Bali. Implementing the ISO 50001:2018 Energy Management System at I Gusti Ngurah Rai, YIA Kulonprogo, and Soekarno Hatta Airports. Implementing a Building Automation System (BAS) and SCADA to monitor electricity usage at Ahmad Yani, YIA Kulonprogo, and I Gusti Ngurah Rai Bali Airports. Renewable energy hybrid systems, such as PV power, effectively manage energy and reduce emissions at the airport of Korea's Incheon International Airpor (Sugiarto, 2016).

Application of Comfort and Health

PT Angkasa Pura I ensures that the results of air quality measurements, including carbon monoxide (CO), sulfur dioxide (SO2), and nitrogen dioxide (NO2) parameters, remain within quality limits.

Application of Water and Wastewater

Carry out wastewater treatment processes using a water treatment recycling system and reverse osmosis technology to recycle brackish water and rainwater at Ahmad Yani Airport, Semarang. Carrying out rainwater harvesting at YIA Kulonprogo Airport. Implement water conservation measures and monitor water quality through monitoring points with satellite imagery at Hong Kong International Airport (Wang et al., 2023).

Application of Materials and Resources

Use of recycled wood and paper instead of plastic, and air conditioning refrigerants that do not damage the ozone layer. Implementation of the Circular Airport Retail Waste Management (CAWM) Model suggests separating waste, improving signage, and training staff for efficient airport waste management, helping sustainability and cost-effectiveness (Tjahjono et al., 2023).

Application of Site and Habitat

Implementation of time integration on the Soekarno-Hatta International Airport Train with Skytrain, with a focus on coordinating schedules to reduce passenger waiting times and increase transportation efficiency. The implementation of habitat, transportation, and resilience at the airport involves

strategies such as waste management, energy efficiency, noise control, and sustainable growth initiatives, as seen at Naples International Airport (Miedico, 2018).

In Indonesia, the implementation of airport sustainability has been actively pursued through various strategies. Airports such as Yogyakarta International Airport (YIA) have achieved Greenship Gold certification, emphasizing the principle of net zero energy development. Syamsudin Noor Airport has implemented green building concepts such as solar panels, bright glass for natural light, and wastewater treatment facilities to support environmental preservation (Ahmad Busairi et al., 2023). This effort reflects Indonesia's commitment to sustainable airport development, which is in line with global priorities for safe, efficient, and environmentally friendly civil aviation.

Conclusions and Recommendations

Sustainable airport policies include a variety of initiatives aimed at reducing the environmental impact of aviation operations. The policy focuses on developing environmentally friendly airports by prioritizing environmental management, training employees on sustainability aspects, and collaborating with various stakeholders.

To address global aviation priorities, a strategic policy implementation approach that involves stakeholder cooperation, compliance with legislation, and a commitment to planning and evaluation is critical to the environmental sustainability of airports.

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