Measuring Scope 3 CO_2 Emissions and Integrating Sustainability in Aviation

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A Capstone Project Submitted to Embry-Riddle Aeronautical University in Partial Fulfillment of the Requirements for the Aviation Management Certificate Program

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Abstract

Aviation contributes to 2.1% of global CO_2 emissions from human activities. It is one of the most challenging sectors to decarbonize, despite established commitments such as achieving Net Zero emissions by 2050. This study addressed a less prioritized area in airlines' sustainability strategies: Scope 3 Greenhouse Gas (GHG) emissions. Scope 3 GHG encompasses indirect emissions from sources not owned or directly controlled by the company. Specifically, the research focused on CO_2 emissions associated with three major airports in Brazil, exploring the challenges and opportunities in measuring and reporting these emissions. Practical solutions to this complex issue require collaboration among various stakeholders in the aviation sector, which was covered in this study. Aviation Scope 3 GHG emissions data and literature were examined to determine the accuracy and transparency in measuring and reporting sustainability practices impacting the industry's value chain.

Key words: climate change; decarbonization; Scope 3 GHG emissions; Airport Carbon Accreditation (ACA)

Introduction

The aviation industry, responsible for 2.1% of global CO_2 emissions, faces significant decarbonization challenges by 2050. Allen et al. (2018), in their document written for the Intergovernmental Panel on Climate Change (IPCC), identify aviation as a growing source of greenhouse gases. The International Air Transport Association (IATA) (2021) emphasizes the need for sustainable aviation fuel globally. The International Civil Aviation Organization (ICAO) (2022), a collaboration of aviation organizations, constantly seeks innovation and regulations to reduce aviation's carbon footprint. These organizations highlight the urgency for aviation to adopt more sustainable practices globally.

Sustainable Aviation Fuel (SAF) is essential for decarbonization but currently meets only 0.15% of demand. Climate change advocates globally (regulators, customers, and environmental activists) pressure aviation organizations to enhance sustainability using SAF (IATA, 2021; ICAO, 2022). Airlines, airports, regulators, and passengers collaborate to achieve decarbonization goals, including SAF (ICAO, 2022). For example, Delta Airlines is investing in SAF to reduce emissions and promote sustainability (Delta Airlines, 2023). Airports like Heathrow track Scope 3 emissions for better sustainability planning (Vidstrom, 2023). Governments, like the European Union, push for sustainable practices to combat climate change (European Commission, n.d.). Passengers are involved in aviation sustainability by influencing demand for greener travel options (IATA, 2021).

Considering the above, studying decarbonization in aviation is crucial for reducing environmental impact. This study examined the challenges of analyzing, measuring, and transparently reporting Scope 3 emissions at three Brazilian airports. The investigation aimed to understand how Scope 3 emissions could help optimize the airports' environmental impact and

achieve Net Zero emissions effectively by 2050. The following Problem Statement and Project Goals continue to introduce the research focus and primary objectives. The Definition of Terms clarifies vital concepts, ensuring a clear understanding of the study's core issues.

Problem Statement

The problem initiating this investigation was that current emission frameworks primarily addressed Scope 1 and Scope 2 emissions. Scope 1 includes direct emissions from company-owned or controlled sources, such as fuel combustion. Scope 2 involves indirect emissions from purchased electricity, heating, or cooling the company uses. Scope 3 refers to all other indirect emissions in a company's value chain, which are often not prioritized.

This research focused on the challenges of reporting Scope 3 emissions at three major Brazilian airports. It further assessed how current methods and incentives influenced emissions reporting and decarbonization strategies. The study recommended improving the measurement and integration of Scope 3 emissions in existing frameworks. Filling these gaps was vital for enhancing understanding of aviation's environmental impact and improving emission reduction strategies.

Project Goals

The main objective of this study was to contribute to the decarbonization of the aviation sector by improving the accuracy and comprehensiveness of the measurement and reporting of Scope 3 greenhouse gas (GHG) emissions. Specifically, the aim was to identify and analyze the current challenges in measuring and reporting Scope 3 emissions at three Brazilian airports. It also aimed to assess the influence of existing methodologies and incentives on reporting emissions and developing decarbonization strategies at the same airports. Finally, the study proposed recommendations for improving the measurement of Scope 3 emissions and their

integration into the existing Brazilian airport reporting structures, with a view to more effective emissions management and developing more robust decarbonization strategies.

Project Scope

The research covered the analysis of Scope 3 emissions from aviation, focusing on three Brazilian airports: Florianópolis (FLN), Campinas (VCP), and Confins (CNF). The research reviewed and analyzed scientific literature on aviation decarbonization, GHG measurement methodologies, and available data on GHG emissions from the three Brazilian airports. A review and analysis of the information might have identified the primary sources of emissions and the challenges to quantifying them.

The GHG measurement and reporting methodologies used at Brazilian airports were compared with international best practices. The research also identified the main knowledge gaps and opportunities for improving the measurement and reporting of Scope 3 emissions. Finally, recommendations were proposed for airport managers, airlines, and other stakeholders to improve GHG emissions management and promote the aviation sector's decarbonization.

Definition of Terms

ACA: Airport Carbon Accreditation is airports' institutionally endorsed global carbon management certification program.

CAF: Conventional Aviation Fuel is fuel produced from conventional hydrocarbons such as crude oil, liquid condensates, heavy oil, shale oil, and oil sands.

Carbon footprint: Carbon is the total amount of greenhouse gases (including carbon dioxide and methane) generated by our actions.

Climate Change: Refers to long-term shifts in temperatures and weather patterns. Human activities have been the main driver of climate change since the 1800s.

Decarbonization: This is about reducing CO_2 emissions from human activity, aiming to eliminate them.

GHG Emissions: The primary greenhouse gases (GHGs) are carbon dioxide, methane, and nitrous oxide. The main anthropogenic activities that increase them are industry, the burning of fossil fuels, agriculture, and the use of fertilizers.

IATA: The International Air Transport Association (IATA) is the trade association for the world's airlines, representing 330 members.

Inventory of Greenhouse Gases: A list of emission sources and the associated emissions quantified using standardized methods.

Net Zero: Net zero emissions means achieving an overall balance between greenhouse gas emissions produced and emissions removed from the atmosphere.

PBGHG: The Brazilian GHG Protocol Program (PBGHG) was created in 2008 and is responsible for adapting the GHG Protocol method to the Brazilian context and developing calculation tools for estimating greenhouse gas (GHG) emissions.

SAF: Sustainable Aviation Fuels (SAF) can be any viable aviation fuel that is certifiably produced in conformity with sustainability criteria, considering both carbon and environmental factors.

Scopes 1, 2, and 3: Scope 1 is those direct emissions owned or controlled by a company. In contrast, scope 2 and 3 indirect emissions are a consequence of the company's activities but occur from sources not owned or controlled by it.

Stakeholders: A stakeholder is a person, group, or organization with a vested interest or stake in the decision-making and activities of a business, organization, or project.

Sustainability: Consists of fulfilling current generations' needs without compromising future generations' needs while ensuring a balance between economic growth, environmental care, and social well-being.

Literature Review

Scope 3 Literature Review Summary

Aviation's contribution to global CO_2 emissions is 2.1%, posing challenges for decarbonization. This literature review focuses on Scope 3 airport emissions, examining measurement, reporting, and reduction strategies. By analyzing studies from various countries, it identifies challenges and opportunities in measuring and reporting emissions. The review explores the integration of sustainability practices in the aviation value chain and emphasizes stakeholder collaboration. Drawing on academic papers, industry reports, and frameworks like the airport carbon accreditation program, this review aims to provide insights for policymakers, airport authorities, and researchers in achieving sustainable aviation operations.

The FAA (2023) offers a comprehensive guide on reducing airport greenhouse gas emissions, focusing on energy efficiency improvements, renewable energy, and emissions monitoring. Financial incentives and case studies promote sustainable practices and carbon neutrality. Similarly, the IATA (2023) report on Sustainable Aviation Fuels (SAF) underscores the importance of SAF in reducing greenhouse gas emissions. Increased production and availability of SAF are essential to meet the industry's sustainability goals. The report discusses the challenges and opportunities associated with SAF deployment, including policy support, infrastructure development, and investment.

Karakoc et al. (2019) explore strategies for reducing emissions, mitigating noise pollution, and minimizing waste generation in their chapter on sustainable aviation practices.

They emphasize the importance of energy efficiency, renewable resources, policy frameworks, and technological innovations in driving positive environmental change. The World Resources Institute's image of global greenhouse gas emissions in 2020 highlights the intricate relationship between economic activities and their environmental impact, underscoring the broader context in which the aviation industry operates. Understanding the differences between Scope 1, 2, and 3 emissions is crucial for effective emission reduction. Scope 1 covers direct emissions, Scope 2 includes indirect emissions from purchased electricity, and Scope 3 encompasses other indirect emissions (Deloitte, 2021). The EPA's Scope 3 Guidance provides a framework for airports to assess and manage these emissions, emphasizing the importance of addressing all three scopes to achieve sustainability.

Scope 3 emissions, the indirect emissions from airport operations and supply chains, form a significant part of aviation's greenhouse gas output. As highlighted by Vidstrom (2023), these emissions are a critical piece of the puzzle in achieving the industry's decarbonization goals. The complexity of measuring and reporting these emissions is a global issue, demanding collaboration among airlines, airports, and regulators.

Reducing Scope 3 emissions takes work. As Bessoles, M. (2022) points out, airports worldwide face significant challenges in this area. However, collaborative efforts with stakeholders are paving the way for sustainable practices. Zurich Airport (2024) and BH Airport (2022), through their ESG reports, demonstrate their dedication to minimizing environmental impact and engaging with local communities.

Brazilian airlines like Azul Airlines, GOL Airlines, and LATAM Airlines have shown a solid commitment to sustainability through their annual ESG reports. From 2022 to 2023, these reports detail their efforts to reduce environmental impact, promote social responsibility, and

adhere to robust governance standards. Such transparency builds trust with stakeholders and aligns with global sustainability goals. The literature reviewed by our group provides a strong foundation for our study, offering a thorough understanding of the airlines' sustainability practices and their alignment with broader environmental and social objectives.

Methodology

This study utilized Greenhouse Gas emissions inventories, annual reports, and the Airport Carbon Accreditation (ACA) program to analyze the sustainability practices of three airports. To gain deeper insights into these airports' operations, a questionnaire with closed questions was distributed to their Sustainability and/or Environmental departments. The questionnaire, detailed in Appendix A, was structured into three sections: sustainability strategy, emissions accounting and reporting, and actions to reduce emissions.

This study aimed to explore the complexities of aviation's Scope 3 CO_2 emissions and to develop strategies for improving their reduction, measurement, and reporting. Additionally, it sought to identify opportunities for integrating airport sustainability practices into the broader aviation value chain, representing a crucial step towards a more environmentally friendly aviation industry. Reducing CO_2 emissions significantly by examining how airport sustainability practices could be incorporated into the aviation value chain was a prime focus for our research. Most important was the advancing energy efficiency, waste management, and natural resource conservation across the sector. Achieving these goals required enhanced collaboration, including pooling information, fostering stakeholder engagement, and integrating diverse perspectives to create collective solutions.

Data Source(s), Collection, and Analysis

Overview

The data sources, data collection processes, and data analysis methodologies employed in this study include the annual reports from three major Brazilian airlines: GOL, Azul, and LATAM, as well as from three airport authorities: BHAirport, Zurich, and Viracopos. Additionally, interviews conducted with airport authorities were instrumental in identifying the scope of disclosure practices. The data collection involved a systematic review of these reports and qualitative insights from the interviews, which helped inform the analysis. This multi-faceted approach allowed for thoroughly examining the operational and disclosure trends within the airline and airport sectors.

Data Collection

Data collection for this study was based on primary and secondary sources, focusing on Scope 3 emissions and sustainability practices in the airline and airport sectors. Secondary data was obtained from the annual sustainability reports of three major Brazilian airlines - GOL, Azul, and LATAM - and three airport authorities - BH Airport, Zurich, and Viracopos. These reports provided essential information on environmental impacts, emphasizing Scope 3 emissions, including indirect emissions from third-party transportation and supply chain activities.

Primary data was collected through structured interviews and a quantitative questionnaire to complement the data in the reports. The interviews with airport authority representatives provided valuable qualitative information on their sustainability strategies, the management of Scope 3 emissions, and the challenges they face in increasing transparency and meeting climate targets.

In addition, a closed questionnaire was distributed to the airport authorities. This questionnaire aimed to collect quantitative data on key areas of sustainability practices, including the existence of formal sustainability strategies, public commitments related to climate change, greenhouse gas (GHG) inventories, and participation in national and international environmental programs. It also collected information on specific actions and plans to reduce airport emissions, such as energy efficiency measures, adopting renewable energies, and using low or zero-emission vehicles.

This combination of qualitative insights from the interviews and structured quantitative data from the questionnaire provided a solid and comprehensive understanding of sustainability efforts in the airline and airport sectors. Using qualitative and quantitative approaches, the study analyzed Scope 3 emissions and broader sustainability initiatives in these sectors.

Airlines Analysis

In their annual reports for 2023, the three leading Brazilian airlines disclose their respective Scope 3 CO_2 emissions in different ways. GOL is the company that only shows the total amount of emissions between 2021 and 2023 without giving further details. LATAM shows Scope 3 emissions for 2022 and 2023 by categories of GHG Protocol. In the case of Azul, in addition to bringing data from 2021 to 2023, it explains the activities that are accounted for and in which categories of GHG Protocol. In this case, for example, it is possible to identify which emissions related to the snacks served on board are counted as "purchased goods and services" and their emissions of the last three years. In other words, the way Azul reports Scope 3 data with more transparency is the best practice among the three companies. Tables with the disclosed information in the airlines' annual report are available below.

Figure 1

Azul's Scope 3 CO_2 emissions in 2023

Emissões em toneladas métricas de CO_2 equivalente (tCO_2e)			
	2021	2022	2023
Escopo 1 – Emissões diretas de GEE*	2.474.302,41	3.089.851,26	3.300.728,83
Emissões biogênicas Escopo 1	92,841	589,86	1.676,97
Emissões indiretas de GEE provenientes da aquisição de energia**	765,946	316,11	398,41
Escopo 3 – Outras emissões indiretas (Escopo 3) de GEE***	3.665,94	871.376,51	1.118.351,82
Emissões biogênicas Escopo 3 ****	485,401	9.762,71	42.598,00

Nota: gases considerados no cálculo: CO_2, CH_4, N_2O, HFC's e CO_2 biogênico.
* Fontes emissoras consideradas: combustão estacionária, combustão móvel, emissões fugitivas e efluentes.
** Fontes emissoras: emissões indiretas pela compra de energia elétrica – abordagem baseada na localização. Importante ressaltar que em 2023 adquirimos energia no mercado livre, tendo zero emissões de Escopo 2 por escolha de compra, com rastreabilidade por I-RECs (certificados de energia renovável) e autodeclarações.
*** Categorias de Escopo 3 consideradas: bens e serviços comprados (*snacks* oferecidos a bordo, alimentação dos voos, bebidas, parafusos, *speed tape*, óleo lubrificante, papel, caixa de papelão, pneus), bens de capital (*leasing* das aeronaves), atividades relacionadas com combustível e energia não inclusas nos Escopos 1 e 2 (emissões da produção de combustível - *Well to tank* - WTT), transporte e distribuição *upstream* (operações de *handling*, *catering*, equipamentos de *push-back*, transporte terrestre das operações da Azul Cargo, serviços de motoboy), resíduos gerados nas operações, viagens a negócios, deslocamento casa-trabalho, uso de produtos vendidos (pacotes de turismo) e franquias (Lojas Azul Cargo e Lojas Azul Viagens).
**** Houve um aprimoramento do rastreio de nossas emissões de Escopo 3, gerando um aumento das emissões biogênicas, principalmente de fontes da categoria T&D upstream.

Figure 2

GOL's Scope 3 CO_2 emissions in 2023

Outras emissões indiretas de gases de efeito estufa (Escopo 3)[1] GRI 305-3

Tipo de emissão	2021	2022	2023
Total de emissões de Escopo 3, em tCO_2eq	49.685	145.537	16.401,23
Total de emissões biogênicas de Escopo 3, em toneladas	4.020	4.107	451,18

1. Os gases incluídos no cálculo são CO_2, CH_4 e N_2O. As emissões de Escopo 3 consideradas foram: transporte e distribuição upstream, resíduos operacionais, viagens de negócios e transporte de empregados. Não houve mudanças significativas nas emissões no ano-base. Utilizamos fatores de emissão e GWP do GHG Protocol, com consolidação por controle operacional. O inventário de GEE da GOL é certificado externamente e publicado anualmente no RPE da FGV.

Figure 3

LATAM's Scope 3 CO_2 emissions in 2023

REPARTIÇÃO DAS EMISSÕES INDIRETAS DE ESCOPO 3[3]

GRI 305-3	UNIDADE	2022	2023
Bens e Serviços adquiridos	t CO_2e	1.100.644	380.599
Bens de capital	t CO_2e	N/A	251.032
Atividades relacionadas com o combustível e energia (não incluída nos escopos 1 ou 2)	t CO_2e	2.030.710	2.390.446
Transporte e distribuição a montante	t CO_2e	37.637	56.606
Resíduos gerados nas operações	t CO_2e	2.091	1.373
Viagens de negócios	t CO_2e	14.582	1.055
Deslocamento dos colaboradores	t CO_2e	12.364	13.656
Ativos alugados a montante	t CO_2e	N/A	N/A
Transporte e distribuição a jusante	t CO_2e	N/A[1]	N/A
Processamento de produtos vendidos	t CO_2e	N/A	N/A
Uso de produtos vendidos	t CO_2e	N/A	N/A
Tratamento no fim da vida útil dos produtos vendidos	t CO_2e	N/A	N/A
Ativos alugados a jusante	t CO_2e	N/A	N/A
Franquias	t CO_2e	N/A	N/A
Investimentos	t CO_2e	N/A	N/A
Outros a montante	t CO_2e	N/A	N/A
Outros a jusante	t CO_2e	N/A	N/A

Airport Analysis

Table 1

Airports Answers

Part	Number Question	Question	BH AIRPORT (CNF)	ZURICH AIRPORT (FLN)	VIRACOPOS AIRPORT (VCP)
1	1a	Does the concessionaire have a sustainability strategy?	Yes	Yes	Yes
1	1a.1	If so, is it a global and/or local strategy?	Local	Global	Local
1	1b	Does the concessionaire have any public commitments on climate change?	Yes	Yes	Yes
1	1b.1	If yes, describe up to three main public commitments to climate change.	-	-	-

1	1b.1	Fill in commitment #1	The annual target for the gradual reduction of emissions must always be lower than the average of the last three years of monitoring.	NET ZERO 2040	-
1	1b.1	Fill in commitment #2	NET ZERO 2044	ELECTRIC CAR IN EUROPE	-
1	1b.1	Fill in commitment #3	-	ETANOL CARS IN BRAZIL	-
2	2a	Does the concessionaire carry out its annual Greenhouse Gas inventory?	Yes	Yes	Yes
2	2a.1	If yes, which category does the inventory fall into?	Scope 1, 2 and 3	Scope 1 and 2 (since 2022) | 3 (2024)	Scope 1, 2 and 3
2	2a.2	Is the Greenhouse Gas Inventory published on the Brazilian GHG Protocol Platform?	Yes	No	Yes
2	2b	Is the airport in the ACA?	Yes	Yes	No
2	2b.1	If yes, at which ACA level is the airport?	Level 3	Level 4	-
2	2c	Does the airport participate in the Sustainable Airports program promoted by ANAC?	Yes - 2023 Award		Yes
3	3a	Are any future actions planned to reduce emissions at xxxx airport and those of the players operating at the airports operated by the concessionaire?	Yes	Yes	Yes
3	3a.1	If yes, describe the three main future actions to reduce emissions planned for xxx airport.	-	-	-
3	3b	There are specific actions at xxx airport to reduce emissions:	-	-	-

3	3b	Low-cost energy efficiency measures	Yes	-	-
3	3b	Purchase of renewable energy	Yes	-	Yes
3	3b	Installation of renewable energy systems at airports	Yes	-	Yes
3	3b	Purchase of low- or zero-emission vehicles		-	-

Sustainability strategies can be observed in three Brazilian airports: BH Airport (CNF), Zurich Airport (FLN), and Viracopos Airport (VCP). Each airport implements unique approaches to environmental management and sustainable initiatives. The differences in their strategies reflect varying levels of progress and commitment to sustainability practices.

Global and Local Sustainability Strategies

BH Airport (CNF) and Viracopos Airport (VCP) implement local sustainability strategies. At the same time, Zurich Airport (FLN) adopts a global approach, reflecting its alignment with broader international trends in combating climate change. Zurich Airport's global strategy may facilitate better alignment with international environmental agreements and guidelines. In contrast, BH Airport and Viracopos's local strategy is likely more focused on addressing regional and Brazil-specific sustainability issues.

Public Commitments on Climate Change

Both BH Airport and Zurich Airport have made relevant public commitments related to climate, with clear targets. BH Airport commits to gradually reduce emissions, aiming to keep emissions below the average of the last three years of monitoring, with a specific target of achieving carbon neutrality by 2044. Zurich Airport is even more ambitious, committing to reach neutrality by 2040 and already implementing actions such as introducing electric cars in Europe. These commitments reflect both airports' seriousness in reducing their carbon footprints. On the

other hand, Viracopos Airport has not yet presented specific public obligations on climate change, which indicates it may still be in the early phase of planning or implementing more structured climate actions.

Greenhouse Gas Emission Inventory

All three airports carry out annual greenhouse gas (GHG) inventories, a crucial step for monitoring and managing their emissions. BH Airport and Viracopos cover Scopes 1, 2, and 3, while Zurich Airport began including Scope 3 only in 2024. Scopes 1, 2, and 3 are essential for measuring direct emissions, indirect emissions (such as electricity), and indirect emissions occurring in value chains (such as passenger travel and cargo transportation). This suggests that all three airports know the need to manage direct and indirect emissions. Still, Zurich Airport may be more advanced in detailing and comprehensiveness in managing indirect emissions.

Participation in Sustainability Programs

BH Airport is committed to sustainability, as demonstrated by its participation in the Sustainable Airports Program promoted by ANAC, receiving the 2023 award. This recognition evidenced the airport's progress in adopting environmental management practices. Zurich Airport, in turn, is involved in the ACA (Airport Carbon Accreditation), reaching level 4, which indicates significant decarbonization actions and deep involvement in global carbon reduction initiatives. BH Airport is slightly behind, with level 3 in the ACA, but still demonstrates consistent progress. Viracopos Airport, on the other hand, seems to be more delayed, with no clear information about participation in these programs or ACA, suggesting it may need to strengthen its sustainability initiatives.

Specific Emission Reduction Measures

BH and Zurich airports have demonstrated clear actions to reduce their emissions, such as low-cost energy efficiency measures, renewable energy purchases, and the installation of renewable energy systems. These initiatives are fundamental to reducing dependence on fossil fuels and improving the overall energy efficiency of the airports. Zurich Airport also stands out for its purchase of low or zero-emission vehicles, an important measure to reduce emissions from ground transportation within the airport. BH Airport adopts similar actions, but Viracopos Airport, according to the data in the table, is not as advanced in these specific initiatives.

The three airports are at different stages of their sustainability strategies. Zurich Airport (FLN) stands out with a global approach, ambitious commitments to carbon neutrality by 2040, and deep involvement in international sustainability programs. BH Airport (CNF) is also making notable progress with clear emission reduction goals and strong participation in the ANAC program, although with a more regional focus. Meanwhile, Viracopos Airport (VCP) seems to be at the beginning of implementing its sustainability strategy.

Project Outcomes

This section addressed how the results answered the research questions and formulated hypotheses. The project analyzed the transparency and sustainability practices of three Brazilian airlines-GOL, LATAM, and Azul- regarding the disclosure of Scope 3 CO_2 emissions in their 2023 annual reports. The sustainability strategies of three airports were also examined: BH Airport (CNF), Viracopos Airport (VCP), and Zurich Airport (FLN). The results showed that GOL has a limited approach, while LATAM and Azul provide more detailed data, with Azul being the most transparent in its practices. Regarding airports, BH Airport and Viracopos adopt local strategies, while Zurich Airport aligns itself with a global approach with more robust

commitments. However, the limitations of the analysis include the need for more detail in GOL's reports and the absence of clear obligations on the part of Viracopos, which suggests that its sustainability initiatives are at an early stage. A complete analysis of the results and limitations is presented below.

Results

The analysis revealed that GOL presents a limited report, informing only the total Scope 3 emissions between 2021 and 2023, without further details. In contrast, LATAM provides data segmented by GHG Protocol categories for 2022 and 2023. Azul stood out by presenting comprehensive information from 2021 to 2023, including a detailed description of the activities accounted for, which positions it as a best practice in terms of transparency.

Regarding airports, BH Airport and Viracopos follow local strategies, while Zurich Airport adopts a global approach that aligns with international trends to combat climate change. BH Airport has committed to keep emissions below the average of the last three years to achieve neutrality by 2044. Zurich Airport is even more ambitious, aiming for neutrality by 2040, with actions already implemented, such as introducing electric vehicles. On the other hand, Viracopos Airport has yet to present clear public commitments about climate change, indicating that it is at an early stage of planning.

All airports carry annual GHG inventories, but BH Airport and Viracopos cover Scope 1, 2, and 3, while Zurich only started including Scope 3 in 2024. Participation in sustainability programs also varies: BH Airport was awarded for its involvement in ANAC's Sustainable Airports Program, while Zurich Airport achieved level 4 in ACA (Airport Carbon Accreditation). Viracopos is at a later stage, with no clear information on its participation in sustainability initiatives. BH Airport and Zurich have implemented specific measures to reduce their emissions,

such as adopting energy efficiency and purchasing renewable energy. At the same time, Viracopos has yet to make significant progress in these initiatives.

Limitations

Limitations of the analysis include the lack of detail in GOL's reports, which prevents a more robust comparison with other airlines. The absence of clear commitments from Viracopos regarding climate action suggests a need for more structure in its sustainability initiatives. In addition, the variety of approaches adopted by airports-local versus global- makes it difficult to compare the effectiveness of their strategies directly. The different stages of implementation of sustainability practices between airports also limit the generalizability of the best practices identified. Finally, limited data availability in some cases, such as the start of reporting in 2022 or 2024, restricts the temporal analysis of the evolution of emissions and sustainability actions.

Conclusions and Recommendations

This next section presents the conclusions and recommendations from the analysis of main Brazilian airlines' Scope 3 Greenhouse Gas (GHG) emissions and the emissions of the three Brazilian airports studied. The conclusions highlight the importance of transparency and collaboration between aviation stakeholders to improve emissions management and drive sustainability. The recommendations address practical strategies that can be adopted by airports and airlines, emphasizing the need to integrate Scope 3 emissions into existing reporting frameworks. The section is divided into two parts: the conclusions, which summarize the most significant findings on emissions management and transparency, and the recommendations, which suggest specific actions to improve sustainability practices in the sector.

Conclusions

The investigation into airlines' Scope 3 Greenhouse Gas (GHG) emissions at Brazilian airports reveals the critical importance of transparency and collaboration between the various aviation stakeholders. The results show that although some airlines and airports are progressing in their sustainability practices, significant gaps exist in measuring and reporting these emissions. This highlights the need for a more integrated approach to emissions management and provides a clear path forward for the industry, showing that collaboration between stakeholders can result in significant improvements. Industry professionals should, therefore, find these conclusions helpful in improving their sustainability strategies and meeting the growing demands for greater environmental responsibility.

Recommendations

Based on the research findings, we suggest two main actions to improve the measurement and reporting of Scope 3 CO_2 emissions. First, we recommend joint actions between airlines and airports to reduce emissions, with the disclosure of these initiatives prominently in annual reports. This would reinforce the importance of collaboration and maximize the visibility of sustainable practices, such as using Sustainable Aviation Fuels (SAF) and other alternatives that deserve more attention.

Secondly, we propose that ANAC introduce a new award that recognizes joint actions between different aviation stakeholders. Currently, the agency has already awarded companies for their initiatives. However, an award focused on collaboration would highlight the interdependence between the various parts of the sector, promoting a more cohesive approach to sustainability.

In addition to these immediate recommendations, we suggest areas for future research that could explore global best practices in emissions measurement and reporting and the effectiveness of collaborative initiatives. Such studies would be valuable in informing and guiding the industry's search for more effective and integrated solutions, ensuring a lasting positive environmental impact.

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Appendix A

INTERVIEW SCRIPT - AIRPORTS

Part 1 - Sustainability strategy

1.a. Does the concessionaire have a sustainability strategy?

( ) Yes ( ) No

1.a.1.If so, is it a global and/or local strategy?

( ) Global ( ) Local

1.b. Does the concessionaire have any public commitments on climate change?

( ) Yes ( ) No

1.b.1. If yes, describe up to three main public commitments on climate change.

Fill in commitment #1

Fill in commitment #2

Fill in commitment #3

Part 2 - Accounting and reporting of emissions

2.a. Does the concessionaire carry out its annual Greenhouse Gas inventory?

( ) Yes ( ) No

2.a.1. If yes, which category does the inventory fall into?

( ) Scope 1 only

( ) Scopes 1 and 2 only

( ) Scopes 1 2, and 3 without third-party audit

( ) Scopes 1 2, and 3 with third-party audit

2.a.2 Is the Greenhouse Gas Inventory published on the Brazilian GHG Protocol Platform?

( ) Yes ( ) No

2.b. Is xxxx airport in the ACA?

( ) Yes ( ) No

2.b.1. If yes, which ACA level is the airport xxx at?

( ) Level 1

( ) Level 2

( ) Level 3

( ) Level 3+

( ) Level 4

( ) Level 4+

( ) Level 5

2.c. Does the airport participate in the Sustainable Airports program promoted by ANAC?

( ) Yes ( ) No

Part 3 - Actions to reduce emissions

3.a. Are any future actions planned to reduce emissions at xxxx airport and those of the players operating at the airports operated by the concessionaire?

( ) Yes ( ) No

3.a.1. If yes, describe the three main future actions to reduce emissions planned for xxx airport.

Fill in action #1

Fill in action #2

Fill in action #3

3.b. There are specific actions at xxx airport to reduce emissions:

( ) low-cost energy efficiency measures

( ) purchase of renewable energy

( ) installation of renewable energy systems at airports

( ) purchase of low- or zero-emission vehicles

Part 4 - Certifications

4.a. Does XXX airport have ACI (Airports Council International) certifications?

( ) Yes ( ) No

4.a.1 If you have ACI certifications, please specify which ones and in which year they were received.

Certification:

Year:

Certification:

Year:

Certification:

Year:

Certification:

Year:

Certification:

Year: