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Catch me if you can: Sustainability meets airport expansion -

Case study with Vienna Airport.

Frederik Wedig Mewes

Dissertation written under the supervision of professor Sérgio Moreira.

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Abstract

This dissertation explores the concept of socially sustainable and responsible airport expansion through a case study of Vienna International Airport's planned third runway. The dissertation develops a master plan grounded in international standards, including the International Finance Corporation (IFC) Performance Standards (PS), Environmental, Health, and Safety (EHS) Guidelines, and International Civil Aviation Organization (ICAO) recommendations, combined with best practices from the aviation industry. A gap analysis evaluates the alignment of Vienna Airport's social management measures with this master plan to identify strengths, gaps, and opportunities for improvement.

The gap analysis reveals that Vienna Airport has implemented numerous measures exceeding legal requirements, such as proactive community engagement through the Dialog Forum (DF), comprehensive noise protection programs, and transparent grievance mechanisms. These initiatives position Vienna Airport as a potential best-practice model for socially responsible airport expansions. However, some gaps remain in areas such as resettlement planning, long-term health impact mitigation, and modern communication strategies like social media engagement. Recommendations for Vienna Airport also include enhancing transparency, developing a Community Health Action Plan, and strengthening resettlement and integration programs.

This thesis concludes that Vienna Airport's approach can serve as an excellent foundation for best practices in socially sustainable airport expansions, particularly with the integration of the proposed recommendations to further align its measures with global standards of social responsibility. While the master plan provides a robust framework for addressing social impacts, its applicability may be limited in regions with less stringent social commitments, highlighting the challenges of global standardization.

Keywords: Airport expansion, runway expansion, Vienna Airport, aviation industry, social responsibility, sustainability, gap analysis, community engagement

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Author: Frederik Wedig Mewes

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Resumo

Esta dissertação explora o conceito de expansão aeroportuária socialmente sustentável e responsável através de um estudo de caso da terceira pista planeada para o Aeroporto Internacional de Viena. Desenvolve-se um plano diretor baseado em normas internacionais, como as Normas de Desempenho da IFC, as Diretrizes EHS e as recomendações da ICAO, aliado às melhores práticas da indústria da aviação. A análise das lacunas avalia o alinhamento das medidas de gestão social do aeroporto com este plano diretor, identificando pontos fortes, lacunas e oportunidades de melhoria.

A análise revela que o Aeroporto de Viena implementou medidas que excedem os requisitos legais, como o Fórum de Diálogo (DF), programas abrangentes de proteção contra o ruído e mecanismos de reclamação transparentes, posicionando-o como um potencial modelo de boas práticas. Contudo, persistem lacunas no planeamento da reinstalação, na atenuação de impactos a longo prazo na saúde e em estratégias de comunicação modernas, como o envolvimento em redes sociais. Recomenda-se o aumento da transparência, o desenvolvimento de um Plano de Ação de Saúde Comunitária e o reforço dos programas de reinstalação e integração.

Conclui-se que a abordagem do Aeroporto de Viena pode servir como uma excelente base para melhores práticas em expansões aeroportuárias socialmente sustentáveis. Contudo, a aplicabilidade global do plano diretor pode ser limitada em regiões com compromissos sociais menos rigorosos, destacando os desafios da normalização global.

Palavras-chave: Expansão de aeroportos, expansão de pistas, Aeroporto de Viena, sector da aviação, responsabilidade social, sustentabilidade, análise de lacunas, envolvimento da comunidade

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List of Abbreviations

CCO: Continuous climb operations

CDO: Continuous descent operations

DF: Dialog Forum

EASA: European Union Aviation Safety Agency

EHS: Environmental, Health, and Safety

ESIA: Environmental and social impact assessment

ICAO: International Civil Aviation Organization

IFC: International Finance Corporation

Leq: Equivalent continuous sound level

Lmax: Maximum sound level

MP: Mediation process

NGO: Non-governmental organizations

NZ: Noise zone

PS: Performance standard

PS1: Assessment and Management of Environmental and Social Risks and Impacts

PS4: Community Health, Safety, and Security

PS5: Land Acquisition and Involuntary Resettlement

SAF: Sustainable aviation fuel

WHO: World Health Organization

WUA: Wiener Umweltanwaltschaft

1 Introduction

Infrastructure development presents many challenges in balancing economic growth with social responsibility. Within the aviation industry, a central question is: "What does socially sustainable and responsible airport expansion mean?" This dissertation addresses this question through a case study of Vienna International Airport's planned third runway expansion, adopting an industry research approach to analyze and evaluate the measures implemented in light of international best practices and standards.

The three pillars of sustainability are environmental, social, and economic. The most addressed issues for communities are noise and local air quality. Environmental aspects like greenhouse gas emissions, water, waste, and land use must also be considered. The industry's goal to grow—specifically focusing on airport expansions regarding runways—makes it even more important to follow strict sustainable mitigation measures (ICAO, 2017).

The research question is highly relevant considering the widespread impacts of airport expansions. While locals suffer from environmental impacts in terms of noise and air pollution, on the other side of the coin lies their vast economic benefits in creating employment, connectivity and staying competitive against other hubs. ICAO states the importance as follows:

"Enabling aviation growth is critical to meeting future demand for air transport and to ensuring that the full economic and social potential of aviation is realized" (ICAO, 2017, p. 12).

The pressure on the industry has reached a never-known level, which is to improve existing and future activities in an environmentally sustainable way, which has the power to harm future growth and development. The aviation industry also offers other great benefits, such as mobility for the people living in the airport's catchment area. At the same time, such mega-projects have a profound restraining impact on the social structure of the local communities. Even though ICAO divides communities into broader and local communities and action groups, the focus remains in this research on the affected local communities. Their proximity to the airport can define them, often resulting by the expansion of cities moving the city's borders closer to out of the city located airports (ICAO, 2017). Many of those communities are "located within the airport noise contours maps" (ICAO, 2017, p. 14).

This development inevitably gives rise to tensions between varied interest groups. Among all these, while the operators of airports and representatives of business underline the need for expansion, the residents and environmentalists often raise considerable concerns. Here, the

conflict is sharp between economic interests on one side and ecological and social concerns on the other. Such tensions must be defused through proactive approaches, referred to as "community engagement," and hand-in-hand with local communities and affected stakeholders. However, most of this engagement from airports is voluntary and not required by law. 71% do more than they are obliged to (ICAO, 2017). Comprehensive noise protection measures, intensive stakeholder participation, and transparent communication are required for trust-building and consensus-reaching. The challenge is finding a way that considers all stakeholders' needs while allowing sustainable and profitable development.

1.1 Thesis outline and ESIA adaptation

This dissertation adopts the format of an Industry Research Report, focusing on actionable insights for real-world applications rather than purely theoretical contributions. The aim is to develop a master plan for socially sustainable airport expansions based on international standards and best practices and evaluate its applicability through a case study of Vienna International Airport's planned third runway. This ensures that the findings are directly relevant to the aviation industry and provide a model for future projects.

The dissertation structure is based on the principles of an Environmental and Social Impact Assessment (ESIA) as defined by the World Bank. It is tailored to analyze the social impacts of the third runway at Vienna Airport. Divided into structured sections reflecting the ESIA framework, it enables a comprehensive evaluation.

The thesis begins with a literature review establishing the foundation for socially sustainable airport expansions. This chapter synthesizes impacts, key research, frameworks, and best practices, including IFC PS, EHS Guidelines, and ICAO recommendations, which shape the master plan.

Next, the project of Vienna Airport is described, and planned measures are outlined. Legal approval procedures and expected impacts provide the context for the expansion. This corresponds to the ESIA's project description section.

A master plan is then developed (see Social management masterplan), serving as a baseline that defines the ideal measures required for socially acceptable airport expansions. This section corresponds to the ESIA baseline chapter and aligns with international standards, frameworks, and guidelines.

The gap analysis evaluates Vienna Airport's existing measures against the master plan, focusing on stakeholder and community engagement, health impacts, and international best practices. It identifies discrepancies between the current status and the goal of a socially responsible airport expansion, allowing for targeted improvement recommendations.

Finally, the dissertation evaluates alternative solutions and insufficient measures, formulating additional recommendations to address gaps and community concerns. This step mirrors the comparison of alternatives in an ESIA, providing actionable proposals for enhanced social compatibility.

Inspired by the World Bank's ESIA approach, this structure supports a thorough assessment of social and environmental impacts while delivering practical recommendations for sustainable airport expansions. The master plan serves as a scalable framework for many airports; however, local specialties, like social, environmental, and health importance, apply. Vienna Airport's expansion positions itself as a potential best-practice model for future projects.

2 Literature Review

Airports are critical infrastructures that not only drive connectivity for businesses and locals in the airports catchment area, tourism, and regional development but also serve as significant economic engines (ACI, 2004; Airport Gurus, 2023).

Airports serve as vital economic drivers, exemplified by Frankfurt Airport, which directly supports approximately 116,000 jobs on-site and through its suppliers and service providers while indirectly generating an additional 59,000 jobs through employee consumer spending. This results in a total economic impact benefiting around 175,000 people. Integrative conflict management plays a crucial role in harnessing these economic advantages while minimizing social conflicts. Frankfurt Airport's Regional DF exemplifies this approach by promoting open dialog between all stakeholders and identifying and resolving conflicts early (Forum Flughafen und Region, 2024; Fraport AG, 2024).

Similarly, Munich Airport significantly contributes to the regional economy. In 2018, companies based at the airport generated a direct gross value added of 3.78 billion euros. When considering broader economic impacts, the total gross value added increased to 6.58 billion euros, with the majority—84%—benefiting the state of Bavaria (Munich Airport, 2022).

Despite the positive effects on employment, airport expansions can also increase living costs. The increased demand for housing and services can increase prices, which places a particular burden on low-income households. In addition, infrastructural burdens such as increasing traffic and environmental factors like noise and air pollution can affect the quality of life (Airport Gurus, 2023).

However, their operations come with considerable social, environmental, and health-related impacts on surrounding communities. Noise and air pollution contribute to stress, sleep disturbances, and long-term health risks, while increased traffic near airports leads to congestion, higher emissions, and additional noise (Vanclay, 2003; Basner et al., 2014; Metzner, 2016). At the same time, airports generate substantial economic benefits, such as creating jobs, attracting investments, and fostering tourism, as seen in Vienna Airport's projection of 32,500 jobs with the third runway compared to 23,000 without it (ACI, 2004; Vienna Airport, 2024).

The challenge lies in balancing these economic benefits with the social and environmental costs. Managing these impacts requires integrating social sustainability into airport expansion projects, which includes comprehensive noise protection measures, effective stakeholder

engagement, and mitigation strategies to address community concerns (ICAO, 2017; Vanclay, 2003). This literature review describes airport expansions' most relevant economic and social challenges, considering noise pollution, health, resettlement, stakeholders, and economic issues. It also deepens social challenges associated with airport expansion and existing strategies and best practices from the literature.

2.1 Social impacts

2.1.1 Noise and air pollution

Aircraft noise is a primary source of background noise near airports and can lead to significant health problems. Studies show that noise from aircraft can cause sleep disturbance, increased stress, and long-term health risks such as cardiovascular disease (Basner et al., 2014). The World Health Organization (WHO) recommends an upper limit of 40 decibels for night-time noise, as higher levels correlate with sleep disorders and their consequences, such as high blood pressure (WHO, 2018).

Long-term studies such as the HYENA study indicate that chronic noise exposure increases the likelihood of heart attacks and strokes (Floud et al., 2011). In addition, night-time aircraft noise impairs sleep quality and cognitive performance, particularly among children. A Europe-wide study showed significant delays in reading comprehension and memory performance in children living near airports (Clark et al., 2006).

Also air pollution from airports has considerable health impacts, in addition to noise. Airports are significant sources of particulate emissions (PM2. 5, PM10) and nitrogen dioxide caused by aircraft engines, ground equipment, and surrounding traffic. Long-term exposure to these pollutants increases the likelihood of respiratory and cardiovascular diseases. A study by the Helmholtz Zentrum München indicates that although the concentrations of pollutants have declined, the health risk has remained high, and air pollution continues to pose a major threat (Dr. Schneider et al., 2024). The combined effect of noise and air pollution can aggravate chronic health conditions. Long-term studies have found an increased risk of cardiovascular disease and shortened life expectancy among people who live near airports. This highlights the urgency of addressing this issue through technological innovation (WHO, 2021).

International regulatory approaches, such as the ICAO's Balanced Approach, provide a framework for reducing noise pollution. This approach comprises four central measures:

reducing noise at the source (e.g., quieter aircraft), land use planning, noise-reducing operating procedures such as optimized flight routes, and operating restrictions such as night flight curfews (ICAO, n.d.-b).

Practical examples illustrate how these approaches can be implemented. Zurich Airport, for example, uses optimized approach procedures to minimize noise in densely populated areas (Zurich Airport, n.d.; Zurich Airport, 2020). Similarly, Heathrow Airport has introduced a noise abatement program that financially supports affected residents with soundproof windows (Heathrow Airport Limited, 2019; Heathrow Media Centre, 2019). These measures combine technical innovations with regulatory requirements to reduce the impact on local residents.

Sustainable aviation fuel (SAF) is an eco-friendly alternative fuel that is gaining traction among airports to combat air pollution. Derived from renewable resources, SAF has the potential to lower CO_2 emissions significantly. However, its adoption is still in its infancy due to limited production and high costs, making it economically less viable. The availability and affordability of SAF are expected to take decades to achieve (ICAO, n.d.-a; Springer, 2017; Austrian Airlines, 2024). Other innovative technologies under development include electric ground equipment and the TaxiBot, a tug vehicle enabling aircraft to taxi without engine power. This innovation nearly eliminates fuel consumption during taxiing. While promising, these technologies remain in the pilot phase and are not yet operational on a large scale (SESAR, 2021; Globes, 2015). These advancements not only support compliance with international environmental standards but also reduce the health impacts regarding noise and emissions of aviation on local populations.

Aircraft noise and air pollution often have a cumulative effect and pose significant health challenges for the population living near airports. The literature and international best practices show that a holistic strategy combining technical innovations and regulatory measures is needed to protect the health of affected communities and promote the sustainable development of airports.

2.1.2 Resettlement and land use

The resettlement of communities resulting from major infrastructure projects, such as airport expansions, comes with far-reaching social and economic challenges. Affected people often lose their livelihoods, leading to impoverishment and social exclusion. One prominent example

is the Three Gorges Dam project in China, where 1.3 million people were resettled, leading to worse living conditions than before (Seeber & King, 2010). Another example is a study by the Federal Office for Building and Regional Planning of Germany, which shows that resettlement in the context of coal mining is often perceived by those affected as a loss of their home and identity, which leads to considerable resistance (Krause et al., 2023). Compared to noise this loss of social contacts and identity can´t be measured in numbers.

International experience shows that a lack of planning and stakeholder participation can lead to considerable tensions. To overcome these challenges, inclusive approaches that consider both the material and immaterial needs of the affected communities are required (German.CHINA.ORG.CN, 2010).

2.1.3 Integration and community engagement

The involvement of the affected population is a key component in the planning of major infrastructure projects such as airport expansions. Insufficient transparency and poor stakeholder engagement can result in severe opposition, protest movements, and a break of trust between airport operators and citizens. Successful public participation is, therefore, crucial to creating acceptance for such projects and minimizing conflicts. (ICAO, 2017; IFC, 2012a, IFC, 2012c).

At Vienna Airport, the mediation process (MP) shows how a participatory approach can be successfully applied, which is considered a best practice case. Residents were involved in the decision-making process early through the DF, which not only increased acceptance of noise abatement measures but also strengthened trust between the parties through transparent communication and the active involvement of the affected population (Vienna Airport, 2024j; WUA, 2018; Vienna Airport, 2024e).

International experience, such as the Heathrow Expansion Public Consultation in the UK, underlines the importance of extensive stakeholder involvement. Public consultations allowed local communities to express their concerns, which ultimately led to adjusted planning decisions (Heathrow Media Centre, 2019; Heathrow, 2019).

Research shows that public participation helps reduce conflict, increases trust, and encourages innovative solutions by integrating local perspectives into planning processes. However,

challenges remain, particularly in designing practical participation formats and overcoming the power imbalance between project developers and affected communities.

2.2 Guidelines and frameworks

The different problems of airport expansions — noise and air pollution, resettlement, and economic impacts — are interconnected in complex ways. Only through a systematic merging of these issues it is possible to create sustainable solutions that balance all three pillars of sustainability.

For example, job creation benefits often conflict with local residents' social and health impacts. Airports serve as key economic engines, yet their growth often comes at a price, creating more noise and air pollution and diminishing the quality of life for neighboring municipalities. To disentangle these conflicting objectives, it is critical not to view problems such as noise reduction, health consequences, and economic impacts in isolation from each other but as interrelated parts.

One example is the Regional DF at Frankfurt Airport, which aims to involve stakeholders from different areas (e.g., businesses, local residents, and environmental associations) and jointly develop solutions. This participatory method shows how an integrated approach can help identify potential conflicts and find targeted solutions (Forum Flughafen und Region, 2024).

Adopting scientific frameworks such as the ESIA, the IFC PS, and the EHS Guidelines provides a structured method for systematically identifying the various challenges and developing solutions.

- **IFC PS:** PS of the IFC are international benchmarks for avoiding and managing environmental and social risks in large infrastructure projects. PS1 (Assessment and Management of Environmental and Social Risks and Impacts), PS4 (Community Health, Safety, and Security), and PS5 (Land Acquisition and Involuntary Resettlement) are particularly relevant here and provide comprehensive specifications on these matters in terms of resettlement, stakeholder engagement, health and safety and how to assess and manage the resulting risks (IFC, 2012a; IFC, 2012b; IFC, 2012c).
- **EHS Guidelines:** The EHS Guidelines, also developed by the IFC and the World Bank, provide detailed technical recommendations for assessing and minimizing the

environmental impact of major projects in terms of EHS. For airports, they provide specific guidelines on topics such as noise pollution, air quality, water management, and health protection. They complement the general principles of ESIA with practical, implementable measures (IFC, 2007).

- **ESIA:** This framework helps to identify the environmental and social impacts of infrastructure projects such as airport expansions at an early stage. ESIA integrates qualitative and quantitative methods to comprehensively assess project impacts. (World Bank, 2017; Gronow et al., 2013; Asia Society, n.d.).

2.3 Links to this project

The literature shows that airport expansions represent a complex interplay of the three pillars of sustainability: social, environmental, and economic challenges. Airports act as important economic engines and create jobs, but they also have a considerable impact on the affected population and environment. Key issues are noise and air pollution, resettlement, and stakeholder engagement.

There is a lack of systematic analyses that provide a comprehensive overview of different measures - based on a compilation of different sources, international standards, best practices, the IFC PS, and the EHS Guidelines - and apply them to a specific local context.

While numerous studies provide important insights into the health effects of noise and air pollution, there is often a lack of interdisciplinary approaches that link these with social and economic factors.

3 Social Impact Management Plan

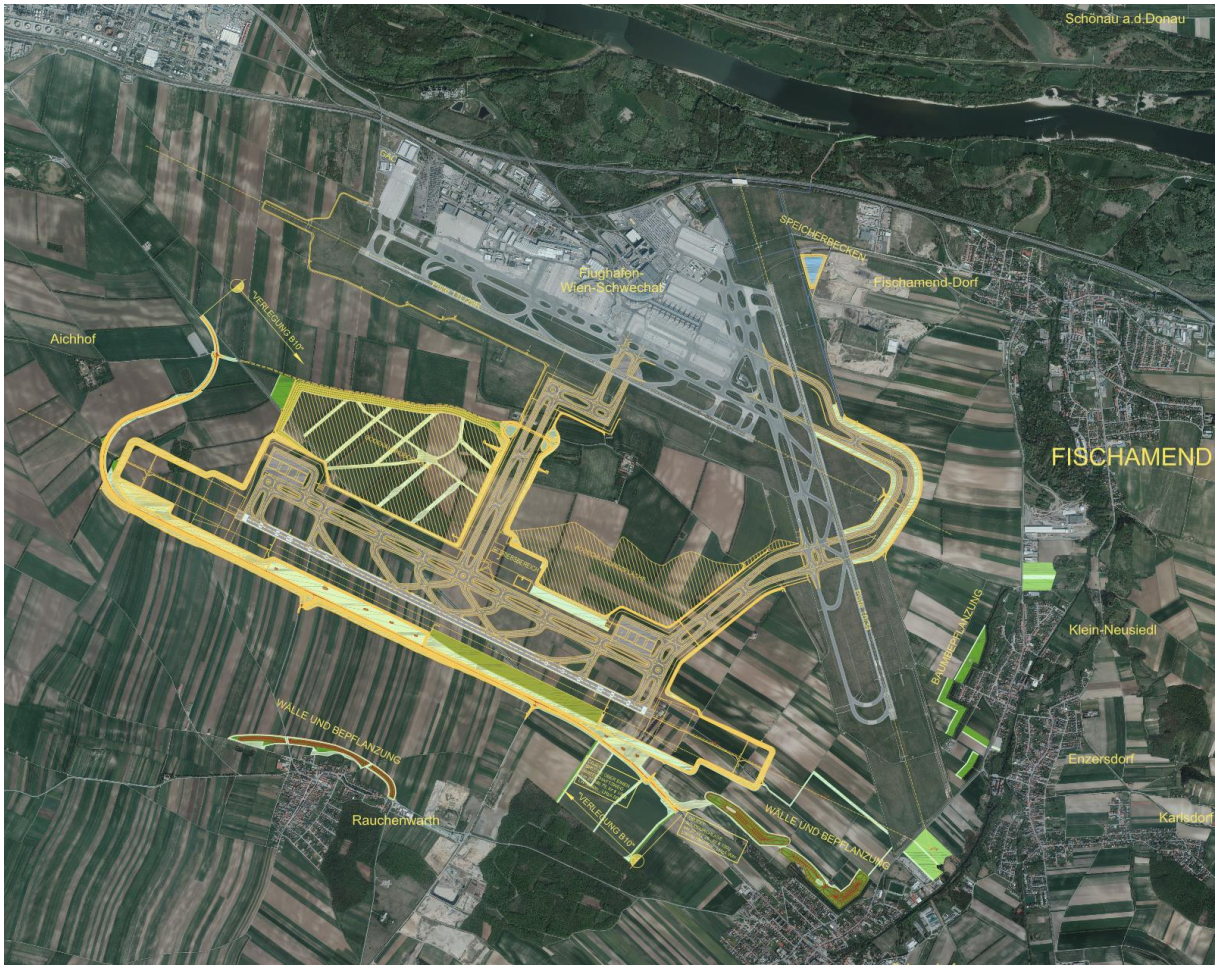
This section thoroughly examines the Vienna Airport expansion. The focus is on the planned construction of a third runway and its corresponding developments and countermeasures. A detailed overview of the infrastructure project is provided, which includes noise abatement measures, environmental mitigation efforts, and community engagement initiatives. The chapter highlights the structured approach taken by Vienna Airport to address the social and environmental challenges posed by the expansion, ensuring that the project aligns with both regulatory standards and the needs of affected communities.

The description and analysis are based on various authoritative sources, including information from the DF of Vienna Airport, mediation agreements, official documentation from Vienna Airport, the website Lärmschutzprogramm.at (including information from 2024 – added information on the renewed website at the end of December 2024 are not included), the Wiener Umwelt Anwaltschaft (WUA), the Mediation Contract, and the Aktionsplan Umgebungslärm 2024 issued by the Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology. These sources provide a foundation for understanding the policies and measures to ensure socially sustainable development.

3.1 Description of the Vienna Airport expansion

In addition to the current expansion of the terminal at Vienna Airport (Röben, 2024), the airport is planning to expand its runway system.

Figure 1. Overview of the runway expansion and corresponding taxiways at Vienna Airport



Source: Vienna Airport, n.d.

The new runway will be located 2400 meters south of and parallel to the current runway 11L/29R. Due to the large distance, it is possible to operate both runways independently of each other. This allows aircraft to land or take off on both runways simultaneously. In addition, the location of the new runway was chosen so that it is the least noisy option, as it is as far away as possible from inhabited areas and therefore does not have to fly over such areas in the initial and final flight phases, as this is where aircraft are loudest and closest to the ground (Vienna Airport, 2024h; Dialog Forum, n.d.-a). Until now, Vienna Airport has not yet owned the land for the expansion (Kurier, 2019).

The runway designations in digits describe the alignment of the runway to the magnetic north pole. This means the current and newly built runway runs in the directions 110 and 290 degrees. The letters "L" and "R" stand for "left" and "right" and are used to distinguish between parallel runways in right and left (Kearns, 2021). The new runway will be named 11R/29L and, like the current runway, will be 3680 meters long and 60 meters wide. Only the runway 29L will be equipped with an instrument landing system (Vienna Airport, 2024h; und Dialog Forum, n.d.-a). This system enables automatic flown approaches to perform landings in poor weather conditions like heavy rain or fog (Cook & Billig, 2017). The system is not installed for landings in the opposite direction (Runway 11R), as this approach route would fly directly over the Vienna city area, which is not permitted according to the MP. Therefore, a curved approach procedure will be used for runway 11R. To connect the runway to the existing infrastructure of the airport, additional taxiways of 30 km will be built (see yellow markings on the map). The entire project would increase the airport's operational area by approx. 30% (Dialog Forum, n.d.).

The project is divided into several sub-projects. The first and most significant phase involves constructing the new runway, establishing taxiways connected to the existing system of runway 16/34, and relocating Federal Road B10. Additional required buildings for the expansion will also be completed in this phase. The second phase includes building another taxiway crossing runway 16/34 to enable independent operation of the two parallel runways. Throughout the first two phases, noise and visual protection measures and planting and landscaping will be implemented continuously. In the final phase, a taxiway between the two parallel runways will be constructed, allowing the crossing of existing runway 11L/29R. The internal road system will also be further extended to integrate the new infrastructure with the existing system (Vienna Airport, 2024h).

3.2 Countermeasures and goals for the planed airport expansion

A Social Impact Management Plan is a strategic tool designed to address social impacts throughout the lifecycle of a project. Developed as part of the impact assessment process and often required by governments or investors, a Social Impact Management Plan outlines strategies, priorities, and resources to mitigate negative and enhance positive social effects. It includes commitments to community engagement, monitoring, reporting, and grievance handling, ensuring an adaptive response to evolving social issues. Social Impact Management

Plans integrate with broader management systems, align with PS, and facilitate ongoing collaboration with impacted communities to promote sustainable and fair development (Franks & Vanclay, 2013; Franks, 2012; Franks et al., 2010).

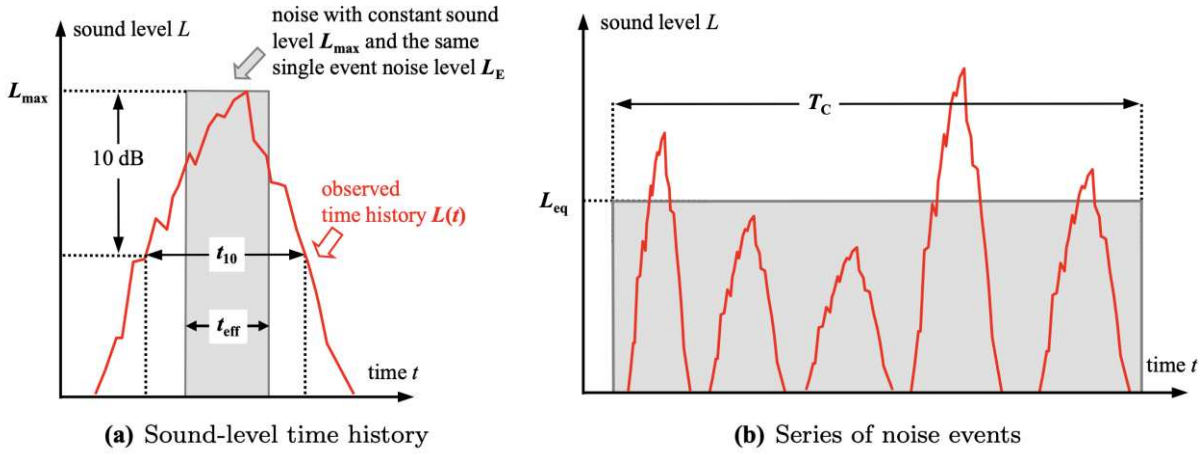
Vienna Airport has developed various measures to cope with the airport's growth in social and environmental terms. These are divided into the following topics: First, various noise zones (NZ) and their respective calculations are explained. These are used to implement various measures to assess how affected a person individually or a household is and enable suitable measures to be taken for this case or this region with equally affected neighbors. In cooperation with the affected stakeholders, the Vienna Airport MP is then outlined. Specifically, it defines how to work together, involve residents, and build mutual trust through participative communication processes. The three main pillars of measures are based on Night Flights, NZ Cap, and the most significant part: Noise Abatement Program.

Vienna Airport is an EU-certified facility, adhering to European Union Aviation Safety Agency (EASA) Regulation 139/2014, which establishes stringent safety requirements for hazardous material handling, fuel storage, and environmental protection measures, also including habitat management and the implementation of measures to mitigate bird strike and to keep a natural environment (EU, 2014).

3.2.1 Definition and calculation of noise zones

NZ define whether and to what extent a residential property is affected by noise from the airport and overflying aircraft. All rooms are analyzed in an acoustic report, and a noise level is determined. The specific noise protection measures to be applied in each room and the amount of the financial subsidy by Vienna Airport (50 or 100%) are based on this measurement (Vienna Airport, 2024d).

Figure 2. Graphical definition of equivalent continuous sound level (Leq) and Maximum sound level (Lmax)



Source: Isermann & Bertsch, 2019, p.290

Vienna Airport employs a detailed approach to NZ calculation and protection, dividing the airport's surroundings into three zones based on daytime sound levels: NZ 1 (54-57 dB Leq), NZ 2 (57-60 dB Leq), and NZ 3 (60-65 dB Leq). At night, zones are defined as NZ 1 (45-50 dB Leq), NZ 2 (50-54 dB Leq), and NZ 3 (54-57 dB Leq) (Vienna Airport, 2024a). These measurements, in decibels Leq, represent a standard noise analysis metric that evenly distributes noise levels over time, as shown in Graph b, where Leq is indicated by the grey area (Isermann & Bertsch, 2019; Rechtsinformationssystem des Bundes, 2012). Interior noise target levels are assigned to each zone, requiring 25-30 dB Leq with closed windows and a maximum of 52 dB Lmax, achieved through technical measures. For comparison, a vacuum cleaner typically produces a noise level of approximately 75 dB(A), urban traffic reaches around 85 dB(A), while whispering measures about 25 dB(A). Zones are calculated based on the six busiest months of the year, exceeding legal requirements considering all 12 months (Vienna Airport, 2024a, Yale University, n.d).

Vienna Airport also incorporates the Sydney Model as a complementary framework in its noise assessment approach to include the frequency and intensity of individual peak noise events. However, it is not globally mandatory. This model, also shown in Graph A, includes the Lmax rather than relying solely on averaged noise levels over time, as with the commonly used Leq metric (graph B). This model assesses single-event noise impacts and their peaks, identifying where aircraft noise exceeds thresholds, such as 65 dB Lmax, which may be more noticeable or disruptive to residents than average noise levels (Leq). Based on the Integrated Noise

Model software from the Federal Aviation Administration, the Sydney Model provides detailed data on isolated, high-intensity noise events (Vienna Airport, 2024d).

3.2.2 Mediation process Vienna Airport

The environmental and social MP concerning all stakeholders about the planned expansion of Vienna Airport is one of the most extensive MP in Europe. It is internationally recognized as a best-practice example of transparent and participative public involvement (WUA Vienna, VIE Dialog). This five-year process started in 2001 and aimed to develop environmentally friendly solutions that would be widely accepted by the society affected and stakeholders from environmental and economic sectors. A total of 50 parties took part in this process, including citizens' initiatives, neighboring communities, the Austrian government, and Austro Control. Through this participative approach, Vienna Airport and the various parties involved aimed to democratize the decision-making processes and to implement conflict resolution measures that the WUA advocated as future-oriented and trend-setting for other airports (Vienna Airport, 2024e; WUA, 2018; Dialog Forum, n.d.-c).

The MP resulted in a legally binding civil law agreement establishing the Vienna DF as a communication platform and creating an environmental fund. In 2007, the noise protection program was expanded to support residents affected by the current two-runway and the planned three-runway systems. The environmental fund by Vienna Airport finances countermeasures, with municipalities and citizens' initiatives jointly deciding on resource allocation (Vienna Airport, 2024e). These agreements created a formal framework for dealing with any future conflicts and concerns relating to airport development in a systematic manner (WUA, 2018). The DF plays a crucial role in the dialog with the people living near the airport and serves as an information and participative communication platform for around 120 municipalities, the City of Vienna, the federal states of Lower Austria and Burgenland, as well as citizens' initiatives. Up to two million people are involved in these participatory processes through their representatives (Vienna Airport, 2024j; WUA, 2018).

The forum meets about four times annually. Complementing these high-level meetings are district-specific conferences that address individual local concerns and impacts of airport operations. These localized meetings, tailored to each district's needs, provide a platform for addressing specific challenges and priorities. Dedicated working groups further explore unresolved issues (Dialog Forum, n.d.-f).

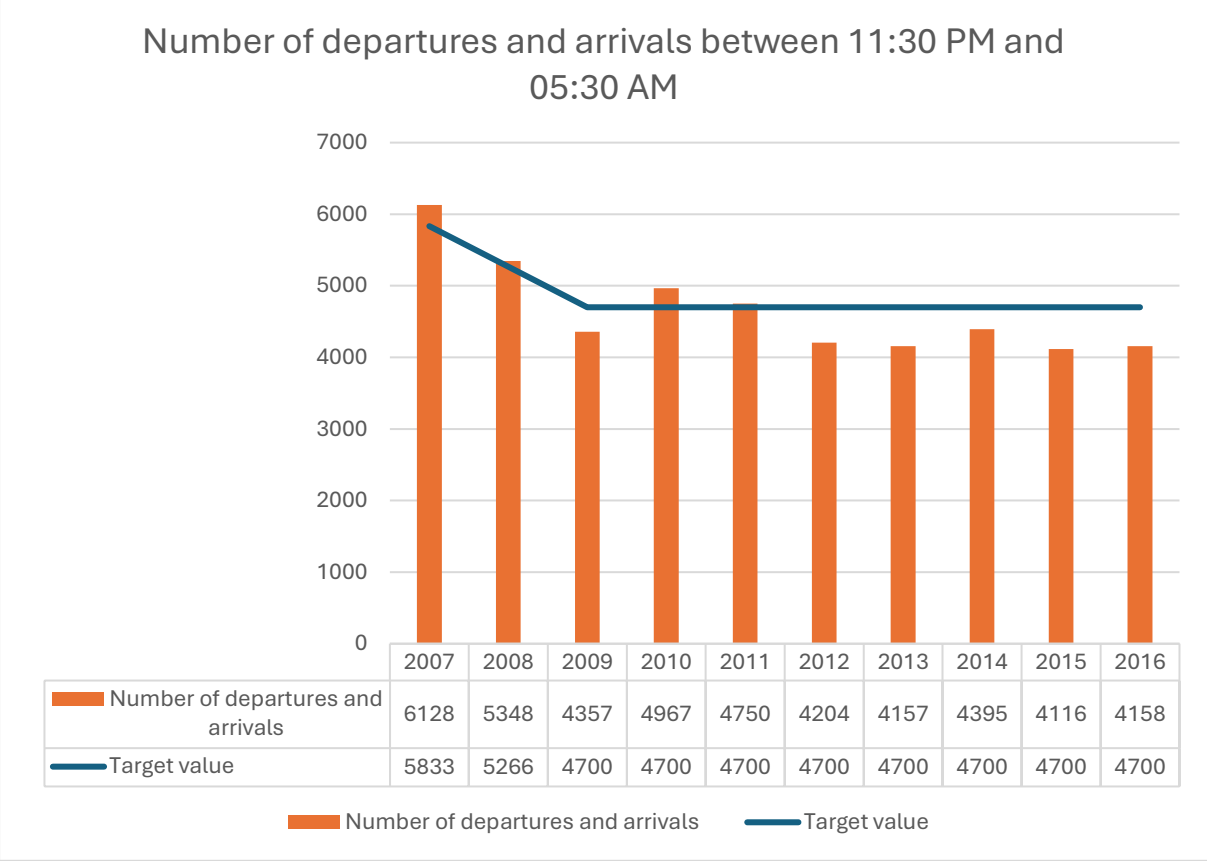
The final agreement contains specific regulations, including the potential location of a third runway, restrictions on night flights, a limit for noise emissions, and noise protection measures (Vienna Airport, 2024j). These agreements are controlled by the DF, which ensures that the defined noise abatement and night flight regulations, as well as the constant improvement of approach and departure routes, are adhered to. In addition, the DF has a guaranteed right to have a say in setting the approach and departure routes in the possible future three-runway system of the airport (Vienna Airport, 2024b).

Vienna Airport makes a financial contribution to the funding of environmental protection measures by paying € 0.20 per passenger during the day and € 0.60 per passenger at night into the environmental fund (Vienna Airport, 2024b). This fund is used to finance projects and measures to minimize the impact of air traffic on the environment and the surrounding communities. The MP and the Vienna DF are internationally recognized as models for transparent, fair, and participative public involvement, and they serve as role models for other airports when designing long-term conflict resolution strategies (Vienna Airport, 2024j; WUA, 2018).

3.2.3 Night flights

A reduction in night flights was agreed as part of the MP at Vienna Airport. According to the agreement, night flights between 23:30 and 05:30 must be limited to 3,000 per year. This number is equivalent to half the number of aircraft movements compared to 2006 and is presumed to be in place once the third runway is in service.

Figure 3. Development of night flights from 2007 until 2016



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Number of departures and arrivals	6128	5348	4357	4967	4750	4204	4157	4395	4116	4158
Target value	5833	5266	4700	4700	4700	4700	4700	4700	4700	4700

Source: Edited by the author based on: Dialog Forum 1, Newsletter, 2017

If the construction of the third runway is delayed or not implemented, a freeze regulation is agreed on. The procedure foresees a step-by-step reduction in night flights. This went on from 2007 to 2010, and then it was frozen in 2010 since the building of the third runway was delayed until today. Consequently, the number of night flights remains constant at 4,700 yearly. The purple bars show a steady undercutting of the target value from 2012 onwards, which indicates consistent implementation of the night flight regulation and compliance with the mediation agreements. This value is valid until a decision has been made on constructing and operating the third runway. However, as soon as a final construction decision has been made, the reduction in night flights will be resumed to comply with the targeted maximum limit of 3,000 aircraft

movements during night per year in the starting year of operation (Vienna Airport, 2024e; WUA, 2018).

3.2.4 Noise zone cap

The placement of the runway ensures that the runway avoids heavily populated areas, thereby reducing the need for land acquisition and relocation of residents. The airport has established buffer zones and NZ caps around the affected areas to mitigate social impacts. The defined NZ serve as a critical tool for identifying and addressing the extent of noise impact on surrounding communities. These zones guide targeted mitigation measures to minimize the adverse effects of airport operations. The concept was developed as part of the MP to ensure that the spatial expansion of noise pollution remains controlled, particularly with the planned operation of the third runway. This approach reflects Vienna Airport's commitment to balancing its operational needs with the well-being of local residents and maintaining compliance with agreed-upon noise limits.

At this time, the agreement also defines the number of noise-affected people. If the noise level is above 54dB, the communities are not allowed to designate new residential areas. This measure prevents additional residents from moving into high-NZ, which could be affected by aircraft noise.

In return, Vienna Airport guaranteed "that the size of the noise protection zones around the airport will not be expanded" (Vienna Airport, 2024e).

This mutual agreement between communities and the airport sets a clear understanding on both sides. Surrounding communities have a clear urban planning process, while simultaneously, residents' long-term noise protection interests are covered (Vienna Airport, 2024e; Vienna Airport, 2005).

3.2.5 Noise protection program

The Noise Abatement and Protection Program established by Vienna Airport forms an integral part of the measures. In the MP, all parties agreed on all measures for both the current two-runway system and the planned third runway. The program addresses the needs of affected residents, focusing on minimizing the impact of noise pollution on health and improving the

quality of life. The program's overall goal is to avoid noise pollution wherever possible and mitigate its effects when avoidance is not feasible (Vienna Airport, 2024c).

One of the program's core objectives is to ensure that a continuous indoor sound level of 30 dB Leq is not exceeded when windows are closed. Additionally, single noise events should not be louder than 53 dB Lmax. These targets are achieved with various noise protection measures, including improving the tightness of windows and doors, replacing old windows, and installing sound-insulating ventilators (Vienna Airport, 2024c).

Vienna Airport supports affected communities and households with their own set-up fund.

Table 1. Measures noise zones during daytime.

	SYDNEY	NZ 1	NZ 2	NZ 3	NZ 4
NOISE LEVEL		*54–57 dB(A)*	*57-60 dB(A)*	*60-65 dB(A)*	*>65 dB(A)*
SUBSIDIZED ROOMS	1 common room	All common rooms	All common rooms	All common rooms	All common rooms
WINDOW EXCHANGE / RETROFIT	50%	50%	100%	100%	100%
SOUND-INSULATING VENTILATOR INSTAL-LATION IN BEDROOMS	No	No	50%	100%	100%
SPECIAL CONSTRUC-TION	50%	50%	100%	100%	100%
REPLACE-MENT	No	No	No	No	Yes

Source: Vienna Airport, 2024m

Table 2. Measures noise zones during nighttime.

	SYDNEY	NZ 1	NZ 2	NZ 3	NZ 4
NOISE LEVEL		*45–50 dB(A)*	*50-54 dB(A)*	*54-57 dB(A)*	*>57 dB(A)*
SUBSIDIZED ROOMS	All bedrooms 50%	All bedrooms 100%	All common rooms 100%	All common rooms 100%	All common rooms 100%
WINDOW EXCHANGE / RETROFIT	50%	100%	100%	100%	100%
SOUND-INSULATING VENTILATOR INSTAL-LATION IN BEDROOMS	50%	100%	100%	100%	100%
SPECIAL CONSTRUC-TION	Yes	Yes	Yes	Yes	Yes
REPLACE-MENT	No	No	No	No	Yes

Source: Vienna Airport, 2024l

The tables, separated by day (6 AM - 11 PM) and nighttime (11 PM - 6 AM), state the individual cost absorption for each NZ, including the Sydney Model.

Specific rules have been developed for the community of Kleinneusiedl, for which a strategic development plan will be carried out. Concrete noise protection measures will be realized with a budget of 12.7 million euros. Furthermore, property owners in NZ 2 and 3 are being financially supported, for instance, in the construction of winter gardens, with Vienna Airport covering up to 18,000 euros for properties in Zone 3 (Vienna Airport, 2024a).

Additionally, there is an option for buying back properties with extremely high exposure, defined as NZ 4, by exceeding 65 dB Leq during the day or 57 dB Leq at night. Property owners in these areas have the right to sell their properties at market value to Vienna Airport (Vienna Airport, 2024a).

Other measures include the Continuous Climb Operations (CCO) and Continuous Descent Operations (CDO). These processes ensure a continuous climb during takeoff and a steady descent below 15,000 feet for the approach phase. By avoiding level-offs and unnecessary throttle adjustments, these operations avoid inefficient vertical speed adjustments that require additional fuel consumption and generate excess noise and emissions that disturb surrounding communities (Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie, 2024; Dialog Forum, 2005).

Another measure involves the construction of noise barriers designed to block or significantly reduce noise from reaching residential communities. These barriers act as effective buffers, minimizing the impact of aircraft operations on surrounding areas. Notably, the soil required for constructing these berms and mounds is sourced directly from the excavation work for the new runway. This approach not only promotes sustainability by maintaining a closed-loop system within the airport's expansion but also eliminates the need for external soil removal or procurement, further enhancing the environmental efficiency of the project (Vienna Airport, 2024h).

Within the DF and based on the results of the MP, Vienna Airport has created a broad noise abatement program, which continues to be extended and adjusted according to needs. Thus, a new noise protection program will be launched, starting in 2025 and continuing up to 2032. It will raise residents' quality of life, with further noise pollution reductions. Vienna Airport provides 24 million euros for this program, which will be used for noise protection measures in the surrounding communities. Compensations of up to 800 euros per square meter of window area can be applied for, whereby a single-family house with 22 m² of window area, for example, can receive up to 17,600 euros (Vienna Airport, 2024g). This dissertation's analysis is based on information available up to 2024. Details regarding measures to be implemented starting in 2025 were only made publicly available at the end of December 2024 and were therefore not included in the evaluation but are mentioned here for reference.

4 Gap Analysis

4.1 Baseline: Guidelines for the social management masterplan

The combination of recommendations from the IFC, including the PS and the EHS Guidelines, forms a robust foundation for addressing social challenges in large infrastructure projects like airport expansions. While the EHS guidelines provide detailed recommendations specific to airports, such as noise abatement, which has the most significant impact on the social acceptance of an airport expansion (Liebe et al., 2020), the focus of this masterplan is on minimizing the social impacts that arise from these environmental challenges.

The IFC PS are particularly valuable in this context, as they make it possible to identify and assess primarily social risks. These standards are more generic and high-level and can, therefore, be adapted and used for diverse infrastructure projects.

The PS1, PS4, and PS5 are particularly relevant for this study, as they address the main topics of the research project. PS1 supports integrating environmental and social management throughout and after the expansion, while PS4 addresses risks to the health and safety of the affected communities. This also includes noise impact. PS5 provides a framework for fair and transparent resettlement processes, often required for large-scale infrastructure projects because the housing as such is no longer viable.

A comprehensive Social Management Plan emphasizes proactive measures that include stakeholder engagement, compensation schemes, and noise mitigation strategies to have a structured framework of lesser adverse impacts on the communities. This approach ensures that all social acceptance of airport expansion aligns with global best practices. By systematically addressing stakeholder concerns, this master plan sets a benchmark for developing socially sustainable strategies for new runways worldwide.

The detailed application of the IFC PS, ICAO community engagement measures, and associated operational, technical, and economic strategies have been moved to the Appendix to streamline the main body of the thesis. These comprehensive guidelines provide the foundation necessary for pursuing a socially responsible airport expansion and serve as the foundational basis upon which the master plan developed in this dissertation has been prepared. Reference to these Guidelines will give stakeholders greater insight into the principles and measures that support the analysis and recommendations proposed in this thesis. Readers are encouraged to consult

the Appendix for a detailed exploration of these frameworks and their practical implications for social impact management.

4.2 Gap analysis: Masterplan and measures applied by Vienna Airport

The gap analysis conducted in this thesis serves as a structured evaluation method to compare the measures implemented by Vienna Airport for the new runway expansion with a Master Plan developed based on international and scientific standards, guidelines, and best practices. This approach assesses the airport's compliance with established measures for socially and environmentally responsible airport expansion.

The analysis follows the structure of tables for clear categorization, as provided in the Master Plan, which shall enable clarity and systematic comparison. Each table is divided into four columns: Measure, Alignment, Recommendations, and Status/Rating.

- **Measure**: Contains the specific measures from the Master Plan, serving as a benchmark for evaluation. This ensures traceability and consistency across the analysis.
- **Alignment**: Describes Vienna Airport's existing actions and policies that align with the respective measures, highlighting areas of compliance. It includes evidence of implemented strategies, adherence to best practices, and proactive initiatives.
- **Recommendations**: Offers suggestions for improvement, identifying steps Vienna Airport could take to meet or exceed the standards outlined in the Master Plan. These recommendations focus on addressing any identified gaps or weaknesses.
- **Status/Rating**: Provides an evaluative classification based on the alignment of each measure, categorized as:
    1. **Overall alignment**: Measures that are primarily compliant, with only minor gaps or non-critical improvements required – marked in green.
    2. **Partial alignment**: Measures where significant aspects are missing or need improvement despite some degree of compliance – marked in yellow.
    3. **No alignment**: Measures for which no evidence of compliance or implementation could be found – marked in red.

This evaluation highlights strengths but also points out opportunities for Vienna Airport. Clear categories of alignment give transparency and a detailed understanding of the gaps. The analysis underlines that continuous improvement and proactive engagement are necessary to align with international standards and stakeholder expectations that guide future strategies towards enhanced sustainability and social responsibility.

4.2.1 IFC Performance standards

Table 3. Gap analysis of the environmental and social management system based on PS1.

Measure	Alignment	Recommendation	Status / Rating
Policy commitments	- Vienna Airport exceed legal requirements by voluntarily implementing stricter noise protection standards which is clearly stated on their website (e.g. during day-time the legal standard is 65dB - Vienna Airport starts at 54dB, and during night-time 55dB (legal) vs. 45dB measures from Vienna Airport start) (Vienna Airport, 2024c; Vienna Airport, 2021). - Noise abatement program with window replacement and buy-back options address displacement concerns (see Table 1 & 2). - Publication of reports: The regular reports, such as the Sustainability Report 2021 or the Environmental Statement, document measures in detail (Vienna Airport, 2024f).	- Develop a comprehensive policy document that systematically consolidates all implemented measures across airport operations, aligning and validating them with national and international standards and regulations.	
Risk identification	- Diverse risks are stated in the Sustainability Report 2021 - Mitigation hierarchy used to avoid noise (specific arrival and approach routes), to minimize (noise abatement program), lastly to cut operations (night curfews and operational hours of specific runways) - The MP included stakeholder input on risks, especially noise and displacement		
Balanced approach to noise management – stated in EU regulation 598/2014	- Reduction of noise directly at source (aircraft) by implementation of a charging scheme based on noise - Land use will be effectively planned by predefined zone, where no new residential areas will be permitted - Noise abatement procedures are implemented as stated in the corresponding chapter. - Operating restrictions are in place for specific runways during specific times and wind directions.		
Noise and vibration management	- The new runway 11R/29L is located at the most favorable position regarding noise impact and replacement regarding the surrounding communities	- No specific departure route for the third runway has been released yet. However, it is very	

	- Noise preferential routes like a curved approach are used for runway 11R to avoid densely populated areas – therefore, no instrument landing system on this runway - Night flights (23:30 until 05:30) have been limited to 4,700 since 2009 and will be further reduced to 3,000 when the third runway becomes operational - CDO and CCO: Aircraft descending below 15,000 feet are guided in a way that ensures a steady and uninterrupted descent to the runway. This minimizes noise and emissions. CCO are implemented to achieve unrestricted climb profiles, avoiding level-offs. They currently account for 40% of operations at Vienna Airport, exceeding the European average. Further improvements are targeted to reduce noise further (Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie, 2024; Dialog Forum, 2005). - Sound barriers are built by the earthworks for the new runway and taxiways.	likely it will be similar to the curved departure route of the existing runway 29R to avoid residential area as more than 50% of all departures will be operated by the new runways 29L (Dialog Forum, n.d.-e). - Improve the 40% success rate of CCO further.	
Collaboration with local authorities	- Due to the DF, Vienna Airport closely collaborates with diverse stakeholders like airlines, affected residents (municipalities), Air Navigation Service Providers, and local governments which represent a total of two million people. - By the nose zone cap, an agreement with local authorities was made to prevent new residential areas in zones exceeding 54 dB, as well the corresponding zones are not allowed to be expanded. This ensures a clear urban planning process. - Local communities are involved in decision-making and can allocate funds by themselves. - Vienna Airport is part of the LEADER region Römerland Carnuntum, which comprises 27 municipalities. This cooperation promotes regional development projects that consider economic and cultural aspects. The aim is to sustainably strengthen the region and improve the quality of life of its inhabitants (Vienna Airport, 2024j).	- Expand collaboration with local authorities to include broader land-use planning frameworks that address air pollution impacts alongside noise reduction.	

Emergency preparedness	- Vienna Airport has a comprehensive emergency response plan in place, including plans for aircraft accidents and natural disasters (Vienna Airport, 2021). - Regular crisis exercises involving airport staff, airlines, and local authorities are conducted, as demonstrated by the large-scale exercise every year in fall. (Vienna Airport, 2023; Wenda, 2023) - High safety standards and robust insurance measures are in place to manage operational risks, such as aviation liability and terrorism.	- Include local communities (residents) as they are not included yet – only authorities.	
Stakeholder and community engagement	- The MP implemented the DF for Vienna Airport, which is a best-practice model for continuous stakeholder engagement and actively engaging communities in participatory decision-making processes for mitigation measures, funds, and infrastructural changes like the new runway. It involves 120 municipalities and represents around 2 million people. - By the grievance mechanism, affected residents have the chance to have a say. - Unresolved issues are further discussed in the working groups within the DF (Dialog Forum, n.d.-b).	- Including environmental non-governmental organizations (NGOs) into the DF.	
Grievance mechanism	- Vienna Airport's DF, Noise Abatement-Hotline, and the contact form on the website of Vienna Airport and flugspuren.at provide accessible mechanisms for all community members to submit concerns. - Noise Protection Program allows affected residents to apply for noise assessment, and thereafter, for financial support of the mitigation measures.	- No anonymous reporting is possible, which could limit participation. - There is no systematic tracking of an opened case by any reporter and its resolution – it is more of a contact form. - Publish annual reports detailing the number, types, and resolutions of grievances to improve accountability and public trust.	
Monitoring and reporting	- By using diverse noise measurement stations around the Vienna Airport, the noise level is monitored continuously. It thus can be evaluated, along with the impact of the different measures and their possible success. The data, reports, and plans for mobile measurements are shown in detail and for several years, on the	- Same as for Policy Commitments (Comprehensive Monitoring of all measures). - Only data is provided in tables and figures. No analysis takes	

	stated website, accessible to everybody. Thus, evolving risks could be observed if they develop over time (Flugspuren.at, 2024). - Other regular updates and reporting are provided through the DF - Feedback can be directly provided on the website of flugspuren.at as stated within the grievance mechanism.	place, which is provided to the communities. Thus, affected residents need to analyze by themselves and check for evolving risks. However, they do not know if this development is also seen by the Vienna Airport and if and what mitigation initiatives they started.	

Table 4. Gap analysis of the community health, safety, and security based on PS4.

Measure	**Alignment**	**Recommendation**	**Status / Rating**
Safe design and construction	- The third runway design ensures the safest possible placement and operation, minimizing risks to surrounding communities by avoiding densely populated areas – also by curved approaches and departures. - New fire station built at new runway. - Wastewater disposal facilities implemented. - Snow storage area. - Special deicing areas.	- Necessary to keep category "high safety" as a standard. The assessment of EASA from 2017 should last during and after the expansion as well. Same applies for the EU Certificate (Vienna Airport, 2017).	
Operational safety management	- Safety zone plan with new runway included has been drawn up (see appendix) (Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie, 2019). - As an EASA-certified airport (Vienna Airport, 2017) it proves that Vienna Airport follows a Safety Management System regarding all regulations and a safe operation (EASA, n.d.). - Regular runway maintenance is communicated via the DF (Dialog Forum, n.d.-d).	- Publish detailed reports on the performance of the Safety Management System, including safety metrics, incident tracking, and improvements. - Update Safety Management System with new arising risks from airport expansion and expected traffic growth.	
Hazardous material management	- OMV pumps kerosene through a pipeline directly to the airport (Vienna Airport, 2021).	- Improve reporting and transparency by regularly publishing inspection results of	

	- Fuels for the vehicles at the apron are delivered to three airport intern gas stations by tanker trucks. - Vienna Airport is EU-certified airport and thus adheres to EASA Regulation 139/2014 to establish safety requirements like hazardous material handling, fuel storage, and environmental protection measures (EU, 2014).	storage for deicing fluids, fuel and the pipeline towards the airport.	
Stormwater and waste management	- The 3rd runway, as well as all other taxiways and apron areas will be sewered. Thus, contaminated wastewater is cleaned in the purification plant. Uncontaminated water is discharged directly via a new sewer into the Danube (Vienna Airport, 2024h). - Specific deicing zones are planed close to the new runway to prevent environmental contamination. Vienna Airport uses environmentally friendly biodegradable glycol mixtures for deicing, directs it into an underground intermediate collecting basin and slowly releases it into the dirty water (Vienna Airport, 2021).		
Community health action plan	- Vienna Airport addresses community health concerns through noise protection programs, including window soundproofing and replacement, ventilation systems, the use of NZ and a reduction of night flights to counteract possible health impacts like stress or poor sleeping conditions.	- No specific plan for long-term effects of noise exposure - Collaborate with Health Authorities: Partner with local health departments to gather data on the health status of affected communities and integrate findings into mitigation strategies. - Open and transparent reporting: Publish periodic health impact assessments and community health updates to foster trust and demonstrate accountability.	
Ecosystem and natural resource protection	- Vienna Airport adheres to the EASA Regulation (EU) No 139/2014, which mandates wildlife hazard management systems for certified airports. This includes habitat management and the implementation of measures to mitigate bird strikes, such as bird detection systems.		

	- Vienna Airport actively preserves biodiversity by maintaining biologically valuable meadows within its grounds, which represent the largest contiguous grassland area in eastern Austria. These meadows, provide critical habitats for a variety of species (Vienna Airport, 2021).		

Table 5. Gap analysis of the land acquisition and involuntary resettlement based on PS5.

Measure	**Alignment**	**Recommendation**	**Status / Rating**
Avoidance and minimization of displacement	- The third runway is planned 2,400 meters south of the existing runway, deliberately chosen to minimize the need for displacement and ensure minimal impact on heavily populated areas. - The location of the runway and the implementation of buffer zones and NZ caps reflect a commitment to reducing social impacts, making this the most socially compatible solution based on the MP and urban planning agreements.	- Justification and comparison of Vienna Airport that the chosen option provides the best possible solution about alternative locations of the new runway. - Secure full ownership of all required land through transparent negotiations, fair compensation, and proactive community engagement.	
Compensation and livelihood restoration	- The measures include provisions for noise abatement and the option for households in high-NZ to sell their properties to Vienna Airport at market value. The last option applies to all households affected by more than 57dB during night and 65dB during the day. (see Chapter Noise Protection Program). - While there is currently no direct program in place to provide retraining or alternative income opportunities for displaced individuals, the increasing traffic and improved connectivity resulting from the airport expansion could enhance the region's attractiveness to businesses. This, in turn, may lead to the establishment or expansion of enterprises, creating new economic opportunities and jobs for the local population.	- There is no direct resettlement assistance in place, such as support in finding new housing or providing replacement housing or apartments, which may be more costly than the original property.	

Resettlement action plan and livelihood restoration plan		- Vienna Airport should establish straightforward programs to restore or enhance displaced individuals' quality of life also on a social level, like community redevelopment initiatives. - Work together with local businesses to create a program for newly arrived residents due to displacement to be integrated into their old sector / industry. Thus, also the local economy is strengthened.	

4.2.2 ICAO community engagement measures

Table 6. Gap analysis of the strategic engagement activities based on ICAO community engagement measures.

Measure	**Alignment**	**Recommendation**	**Status / Rating**
Systematic approach	- With the DF, Vienna Airport has established a long-term engagement platform to interact with affected residents and communities. These stakeholders can address their concerns, which can be discussed with all stakeholders, and joint solutions can be found. - Measures, based on the MP (Sydney Noise Model, the lower limits of Leq dB, and the financial contribution to environmental funds), go far beyond the legal requirements, indicating the airport's commitment to determination for a sustainable coexistence with the surrounding neighborhoods (Vienna Airport, 2024e).		
Proactive and early engagement	- Vienna Airport established the DF in 2001, shortly after initial discussions about the future need for a third runway arose due to increasing air traffic demand. Although the runway received final		

	approval only in 2020 and will be built until 2030, the planning and engagement process began nearly two decades earlier, reflecting a proactive approach to stakeholder involvement (Dialog Forum, n.d.-c; Die Presse, 2023). - In the DF, upcoming topics, issues, and the general feeling of affected stakeholders are consistently addressed and discussed. - The DF serves as a platform for continuously addressing and discussing upcoming topics and concerns from affected stakeholders, ensuring their voices are consistently heard and considered. - Regular communication through "Dialog_aktuell" ensures stakeholders are informed consistently about all developments, trends, and meeting schedules.		
Tailored engagement	- Vienna Airport adopts a highly tailored and individualized approach to engaging with communities on their concerns and issues. The DF and the MP are recognized as distinctive and innovative frameworks. These initiatives are considered exemplary within the aviation industry and serve as a benchmark for effective community engagement.		
Transparency	- DF is a recognized platform that fosters transparent communication by sharing updates, measures, and agreements with stakeholders, including community representatives, to make decision-making understandable for everybody. - Website like flugspuren.at, laermschutzprogramm.at, dialogforum.at, and the website of Vienna Airport provide valuable, easy-to-understand information, documents, graphics, and next appointments on current measures, specifically on plans for the third runway. - The mediation agreement provides legally binding (civil law contract) transparency commitments (Vienna Airport, 2005). - - Several times a year, "Dialog_aktuell" is published, which provides regular updates from the DF's management to its members and district conferences, summarizing the forum's activities, current topics, and upcoming meeting schedules.	- Currently, no information is available indicating whether brochures, newsletters, or posters are provided in printed formats by the DF for residents without internet access. If such materials are not already available, ensuring their distribution to affected communities is strongly recommended. This would enhance accessibility and inclusivity, ensuring that all residents, regardless of internet access, are informed about the	

		airport expansion project and related measures.	
Expectation management	- The establishment of diverse working groups enables targeted action by incorporating inputs from affected communities. This approach demonstrates that stakeholder feedback is acknowledged and taken seriously, with concerns being systematically addressed within the framework of the DF through focused efforts in these specialized groups.	- Proactively acknowledge limitations in addressing every concern and provide clear explanations for trade-offs made in decision-making.	
Collaboration	- Vienna Airport's DF actively involves a broad range of stakeholders, including local governments, community representatives, and environmental groups. - The mediation contract provides a framework for collaboration, ensuring participation of over 50 parties, including political leaders and citizens' initiatives.	- Expand the network of stakeholders by NGOs and small local businesses in the vicinity of the airport. This approach would ensure broader input and foster a more inclusive collaboration process. Additionally, by involving small businesses, opportunities can be created for resettled residents to secure employment within the economically strengthened region and creating a mutually beneficial ecosystem resulting from the airport expansion.	
Build trust	- Vienna Airport provides with its Platform DF a structured approach for ongoing community engagement, dialog, and a feedback loop (Grievance Mechanism), which creates trust. - Noise mitigation programs, night flight restrictions, and compensation measures – also financially - demonstrate tangible responses and outcomes to community concerns and upcoming issues. - Communities and their representatives are continuously and directly (not via third parties) involved in the DF's regular meetings. Specialized representatives are part of the working groups that work on specific issues and their mitigation.	- Enhance transparency further by clearly demonstrating how concerns and feedback from the community are integrated into projects and measures. This approach should showcase, in an accessible and understandable way, that community input is valuable and directly influences decision-making processes. Providing tangible and straightforward proof of this	

	- The proactive and early engagement approach helped to build trust over the last two decades.	integration will foster trust and reinforce the community's confidence in their role within the engagement process. - Improve anonymity regarding reporting / grievance mechanism.	
Evaluate engagement effectiveness	- Vienna Airport tracks specific complaints and has mechanisms for handling grievances through the DF, Noise Abatement-Hotline, and the contact form on the website of Vienna Airport and flugspuren.at.	- Develop a publicly accessible dashboard that provides an overview of community complaints and the overall perception of airport operations' impacts. The dashboard should include metrics on community satisfaction and display trends over time, ensuring transparency and fostering stakeholder trust.	

Table 7. Gap analysis of the technological approach based on ICAO community engagement measures.

Measure	**Alignment**	**Recommendation**	**Status / Rating**
Modeling and visualization	- Vienna Airport employs visualizations like layout maps, NZ, and flight paths for the new runway, with interactive maps on flugspuren.at showing actual aircraft routes. - Noise level developments and number of night flights are shown in well-structured graphs and diagrams.	- Use 3D modeling and innovative VR simulations to illustrate routes and noise levels, helping residents evaluate options for informed decisions.	
Internet-based communication	- Vienna Airport actively uses its website and platforms like the DF and the website laermschutzprogramm.at portal, to provide updates, share reports, show mitigation measures, and engage with stakeholders. - The Noise Protection Program which can be accessed on the website laermschutzprogramm.at will have a new dedicated online	- Enhance social media presence for real-time community engagement, post updates, and respond to inquiries in real time, especially targeting younger audiences.	

	portal for information and funding applications starting in 2025, replacing the existing one.	- Conduct recurring online surveys to track and understand community sentiment and improve countermeasures effectively by facilitating continuous improvement and targeted responses.	

Table 8. Gap analysis of the face-to-face meetings based on ICAO community engagement measures.

Measure	**Alignment**	**Recommendation**	**Status / Rating**
Public meetings / announcements	- Vienna Airport's DF conducts regular meetings with community representatives, municipalities, and other stakeholders, proving ongoing engagement. - District-level conferences address localized needs and impacts, complementing broader DF meetings to ensure area-specific concerns are represented and addressed.	- Organize larger, open public forums in addition to representative meetings to allow broader community involvement for everybody, also from NGOs. - Host localized meetings (on markets or townhalls) in highly affected areas to offer a more accessible platform and to foster direct and informal dialog.	
Targeted meetings and working groups	- Vienna Airport implemented working groups within the DF to address specific issues such as noise management and environmental impacts, fostering targeted discussions and collaborative problem-solving for local concerns.		

Table 9. Gap analysis of print and other media based on ICAO community engagement measures.

Measure	Alignment	Recommendation	Status / Rating
Newspaper and newsletters	- Vienna Airport's "Dialog_aktuell" newsletter provides regular updates on DF activities and airport projects to stakeholders. - The DF, its initiatives, and the renewed noise protection program starting in 2025 are consistently featured in (online) newspapers (Noe ORF, 2024).	- To reach residents without internet access, distribute printed copies of "Dialog_aktuell" in public spaces such as community centers, libraries, town halls, and municipal offices.	
Mail-outs	- Vienna Airport, through the DF, sends out "Dialog_aktuell" newsletters and other updates, ensuring key stakeholders are informed.	- Introduce personalized mail-outs to address specific community concerns or highlight relevant updates tailored to individual stakeholders. - Include invitations for surveys or consultations to gather direct feedback from targeted groups.	
Document publication	- Vienna Airport publishes project-related information, including environmental reports, noise protection measures, and mediation agreements, in easy accessible way for everybody with internet access and in understandable language for layman on its own and partner website, like the laermschtuzprogramm.at or dialogforum.at.	- Offer translations into other languages relevant to the local population and ensure printed versions are available for non-digital audiences.	

Table 10. Gap analysis of the community relationship building based on ICAO community engagement measures.

Measure	Alignment	Recommendation	Status / Rating
Educational programs	- Vienna Airport offers apprenticeship training in various technical professions. - Cooperation with WIFI Lower Austria to set up the "AirportCity Academy," which provides training programs for the region.	- Introduction of educational initiatives for local schools to give pupils an insight into aviation and its impacts.	

	- Cooperation with schools is mentioned in the 2023 Annual Report but not defined in more detail (Vienna Airport, 2024k).		
Others	- Sponsoring local centers like the Socio-educational support and advice center (Sozialpädagogische Betreuungs- und Beratungsstelle , n.d.).	- Expand community engagement efforts by sponsoring local, cultural, or sports events and collaborative community projects and highlighting them online on their website.	

Table 11. Gap analysis of the sustainability and climate change mitigation based on ICAO community engagement measures.

Measure	**Alignment**	**Recommendation**	**Status / Rating**
Adjusting schedule of airport and runways	- Vienna Airport has implemented restrictions on night flights as part of its mediation agreement (see Figure 3). Additionally, each runway direction has different operating hours for landings and departures separately (Vienna Airport, 2005).		
Precise routing and clean configuration	- Vienna Airport employs Area Navigation and Standard Instrument Departures for more precise routing, enabling improved noise containment during departures. Additionally, aircraft are encouraged to maintain a "clean configuration" for as long as operationally possible. This measure minimizes additional noise caused by increased drag when retracting the gear and deploying flaps, typically used to enable lower-speed flight (Sadraey, 2023).		
Single-engine taxi	- Austrian Airlines, the Austrian Flag Carrier with its base in Vienna, stated in 2019 that they already implement Single Engine Taxiing, achieving a reduction of approximately 11,000 tons of CO2 annually (Austrian Airlines, 2019).	- There are no official statistics on the percentage of flights utilizing this practice by Austrian Airlines nor any related information provided by Vienna Airport. Introducing clear reporting mechanisms and transparent data would enhance accountability and support broader adoption of	

		this environmentally beneficial practice. - Vienna Airport could mandate measures requiring airlines to utilize single-engine taxiing on designated routes to the new runway.	
Longer distance aircraft towing		- No Information provided here. However, it is very worthwhile to consider this measure as it saves up to 85% of fuel consumption during taxiing. Additionally, this practice lowers emissions and minimizes noise pollution. Especially interesting for the long taxi distance towards and from the new runway 11R/29L. A provider like "TaxiBot" already exists and tested with Lufthansa. Close cooperation between the airport and the airline is necessary (SESAR, 2021; Globes, 2015).	
Alternative jet fuels	- Collaborations for SAF Supply: Vienna Airport has partnered with OMV and AEG Fuels to introduce SAF, enabling end-users to replace conventional jet fuel with SAF at the airport (Shin, 2022). - Currently, non-fossil aviation fuels account for only 0.1% of the global fuel demand. Within the Lufthansa Group (with one of its Hubs being Vienna), however, SAF has already contributed to covering 0.2% of the required fuel—double the global average (Austrian Airlines, 2024).	- Incentivize Airline Adoption of SAF by offering discounts on landing fees for flights using SAF. - Expand the network of airlines utilizing SAF. - Increase the availability of SAF as the SAF used from the Lufthansa Group used in 2022 equaled only 0.2% of the entire fuel consumption (Austrian Airlines, 2024).	

High speed runway exits	- Vienna Airport has undertaken renovations to broaden taxiway fillets (PORR AG, n.d.). - New Runway is designed and planed with high-speed runway exists along the entire runway length and in both directions (see Figure 1).		
Noise and emission related charges	- Vienna Airport has introduced a differentiated noise charge system, incentivizing airlines to deploy quieter aircraft by imposing higher charges for louder planes. Such measures align with industry best practices to reduce noise pollution. Similarly, environmental charges are incorporated to penalize high emitters (Vienna Airport, 2024i).	- Integrate SAF utilization into the airport's charging scheme by offering reduced fees for aircraft operating with SAF. This incentive would promote the adoption of SAF and lower emissions.	

5 Discussion

The primary objective of this dissertation was to assess Vienna Airport's social impact management measures regarding its planned third runway expansion, using a baseline aligned with international standards, including IFC PS and EHS Guidelines, alongside industry best practices and recommendations from ICAO. In the gap analysis, the dissertation aimed to demonstrate the alignment and shortcomings of current measures at Vienna Airport for a socially sustainable airport expansion and give recommendations for best-in-class results.

The gap analysis reveals that Vienna Airport aligns strongly with many aspects of the master plan, positioning itself as a potential best-practice model for airport expansion projects. Positive highlights include its noise protection program that exceeds legal requirements, proactive and ongoing engagement created by the most extensive MP in Europe, the DF, and the restriction of night flights. Noise charges, emission charges, access to information platforms, and periodic meetings with the affected communities are reasonable indications of Vienna Airport's transparency and involvement and highlight the airport's role as a benchmark for community engagement and sustainable development in the aviation sector.

On the opposite side, the gap analysis revealed missing resettlement planning, anonymous grievance mechanisms, use of internet-based communication tools, and use of social media, which is increasingly relevant when involving younger generations. In that sense, addressing such gaps would further strengthen the social impact framework of Vienna Airport and make it a best-practice model for responsible airport expansion, balancing operational needs with the rights of local communities.

5.1 Evaluation and recommendations for social impact management plan

5.1.1 Transparency

Vienna Airport aligns strongly with the principles of PS1, showing commitment to noise protection programs, proactive stakeholder engagement, and adherence to best practices such as the mitigation hierarchy and the Balanced Approach. Strategic measures include runway placement, curved flight paths, and noise barriers that show efforts toward minimizing social

and environmental impacts. Transparency is further supported through platforms like flugspuren.at and regular updates via "Dialog_aktuell," ensuring accessible communication with stakeholders.

However, the absence of a consolidated document summarizing all social initiatives, legal compliance, and voluntary measures limits transparency and public trust. Developing a comprehensive report to consolidate these measures would provide clear evidence of Vienna Airport's efforts and foster greater trust. Besides, the existing grievance mechanisms lack options for anonymous reporting and annual summaries of documented complaints and resolutions, reducing inclusivity and transparency.

Zurich Airport is a best-practice example of the systematic tracking and annual publication of trends in noise complaints, allowing it to be held accountable and enabling effective monitoring by stakeholders of the various noise mitigation strategies. Similar approaches could be used by Vienna Airport could use similar approaches to enhance interaction with local communities, increase transparency, and demonstrate its commitment to concerns in a measurable and trustworthy way.

5.1.2 Long-tern well-being

One key way community health and safety needs have been successfully addressed at the Vienna Airport is through the strategic placement of the runway and the curved approaches and departures, which minimize residential area noise exposure. Noise monitoring systems, night flight restrictions, and noise charges ensure reduced impacts on surrounding communities.

The most significant deficiency is that there is no Community Health Action Plan devoted to long-term health effects such as sleep disturbances and stress from noise pollution. It could go further by coordinating with local health departments and adding financial support to community well-being for treatments resulting from noise. This also includes a close collaboration with health insurance.

Through such an extended health action plan, existing gaps would be covered, and Vienna Airport would be in a position to confirm its commitment to social sustainability by increasing the general public's confidence in this institution. The Vienna Airport should collaborate with the city's health authority in this respect because health is the most important dimension of social sustainability.

5.1.3 Empowered resettlement

The location of the third runway reflects thoughtful planning to minimize displacement and societal disruptions. At the same time, noise cap zones provide a fair and systematic approach to addressing the needs of affected residents. These measures demonstrate Vienna Airport's efforts to mitigate the social impacts of its expansion.

However, the compensation scheme for property buybacks is limited to market value, failing to account for additional costs such as securing new housing or devaluing properties near the airport. Furthermore, there are no social reintegration programs or resettlement assistance for displaced individuals. To address these gaps, Vienna Airport should introduce compensation schemes that bridge the financial imbalances caused by relocation and implement community redevelopment programs to integrate displaced individuals into their new neighborhoods. These initiatives would significantly improve the airport's alignment with PS5.

5.1.4 Inclusive cutting-edge engagement

Vienna Airport's DF is regarded as a best-practice model for long-term community engagement. The DF fosters proactive and participative engagement through regular meetings, localized district-level conferences, and working groups that involve stakeholders in decision-making processes. Information platforms like *laermschutzprogramm.at* and the upcoming updates to the noise protection program further enhance accessibility and transparency.

Despite these strengths, there is room for improvement. Public meetings are currently limited to invited stakeholders and community representatives, excluding broader participation from NGOs and underrepresented groups or persons affected. Additionally, proactive measures to engage elderly or digitally excluded residents, such as distributing printed materials, are lacking. To enhance inclusivity, Vienna Airport should host open public forums in accessible spaces like town halls, expand stakeholder engagement to include NGOs, and provide printed materials and translations to reach all demographics. Furthermore, offering detailed explanations of decision-making processes and how community feedback is incorporated could build even greater trust. Establishing an interactive social media platform would also enable faster and more direct communication with stakeholders. Overall, Vienna Airport's community engagement is exemplary, with the DF serving as a best-practice model for proactive and participative stakeholder interaction. By integrating modern trends such as increased social

media presence and broader inclusion of NGOs, the airport can further adapt its already robust engagement framework to evolving societal expectations and needs.

The DF of Vienna Airport is regarded as one of the best-practice models for long-term community engagement. The DF stimulates proactive and participative involvement via regular meetings, district conferences at local level, and working groups in which stakeholders are involved in decision-making. Information platforms like laermschutzprogramm.at and the release of any updates of the noise protection program further improve the accessibility and transparency of information.

Despite these strengths, there is room for improvement. Meetings are currently limited to invited stakeholders and community representatives, excluding broader participation from, e.g., NGOs and other persons affected by the open public. Additionally, proactive measures to engage elderly or digitally excluded residents, such as distributing printed materials, are lacking. To be even more inclusive, Vienna Airport could hold open forums for the public in accessible venues such as town halls, extend its stakeholder communications to include NGOs, and make printed materials and translations available as needed. Again, building trust involves providing clear explanations regarding the process and how inputs from the community are dealt with. Then again, an interactive social media platform would allow faster and more direct communication with the stakeholders. All in all, community engagement by Vienna Airport is exemplary, while DF is a best-practice model for proactive and participative stakeholder interaction. This already strong framework of engagement could be brought up and adopted by the airport to meet evolving societal expectations and needs, such as increasing trends like social media presence or the broader inclusion of NGOs.

5.1.5 Sustainable aviation policy

Vienna Airport has implemented various measures to support sustainability and climate change mitigation. Night flight restrictions and noise charges incentivize quieter, more environmentally friendly operations, while collaborations with OMV and AEG have led to SAF usage exceeding the global average within the Lufthansa Group. High-speed runway exits further emphasize operational efficiency, reducing emissions and noise and thus impact on surrounding communities. Precise Area Navigation and Standard instrument departures are in place to avoid residential areas at low heights and to ensure minimal noise disturbance by directing flight paths away from densely populated residential areas.

However, SAF adoption remains limited, also worldwide, with only 0.2% within the Lufthansa Group, of total fuel requirements currently met. Additionally, there is no transparency regarding adopting single-engine taxiing or implementing long-distance towing practices, which have shown promising test results at other airports. To address these issues, Vienna Airport should expand SAF adoption through incentives, increase infrastructure for SAF accessibility, and develop reporting mechanisms for single-engine taxiing. Encouraging long-distance towing measures, supported by insights from other test cases, would further reduce emissions and align with sustainability goals worldwide.

5.2 Limitations

This study is based on publicly available data and information provided by Vienna Airport and its initiatives, such as the DF, community engagement activities, official platforms, and official documents of the ICAO, the IFC, and EHS. The master plan was developed using these publicly accessible sources, ensuring transparency by relying on the same information available to the general public and directly affected communities. The gap analysis identified alignment and improvement opportunities from the perspective of external and publicly shared measures, offering a comprehensive evaluation within the scope of available data.

However, the analysis does not include insights into internal processes at Vienna Airport or within the DF. Additionally, no direct interviews were conducted with representatives of Vienna Airport, members of the DF, or affected communities. While this does not diminish the value of the findings, incorporating such qualitative inputs or peer reviews by mentioned stakeholders could provide a more nuanced understanding of internal decision-making processes and communities experiences, thereby complementing the existing analysis. These methodological constraints slightly limit the breadth of the evaluation but still provide a valuable assessment based on publicly accessible measures and frameworks.

A significant limitation of the master plan lies in its potential applicability across regions with varying social engagement and governance levels. In less socially progressive regions or countries with weaker regulatory frameworks, the principles and measures outlined in the master plan may face significant challenges in implementation. In such contexts, large-scale infrastructure projects, such as airports or new runways, are often executed without meaningful consultation with affected communities or consideration of their concerns. The lack of community engagement and stakeholder involvement in these areas stands in stark contrast to

the socially responsible practices outlined in the master plan. The master plan's universal adoption may be unrealistic, given disparities in social priorities and governance between developed and less socially proactive regions. Although it presents an ideal framework for socially sustainable airport expansion, its global applicability is constrained by varying socio-political contexts.

6 Conclusion

This dissertation explored what constitutes a socially sustainable and responsible airport expansion, using Vienna Airport's planned third runway as a case study. The research leveraged a gap analysis to compare Vienna Airport's measures with a master plan developed from international standards such as the IFC PS, EHS Guidelines, and ICAO recommendations. The findings reveal that Vienna Airport has implemented numerous initiatives that align with global best practices, particularly in areas such as noise protection, overall stakeholder and community engagement, and diverse sustainability and relief measures, positioning itself as a potential role model for socially sustainable airport expansions.

However, the analysis also identified areas requiring attention. Key gaps were noted in integrating anonymous grievance mechanisms, creating a comprehensive community health action plan, and more inclusive engagement strategies that address the needs of digitally excluded demographics and NGOs. Incorporating a robust social media presence and adopting modern, innovative communication strategies will be essential for Vienna Airport to enhance its engagement with diverse stakeholder groups and align with contemporary communication trends. Addressing these limitations is critical to further strengthening the airport's social sustainability framework.

The dissertation underscores the importance of balancing economic benefits by expanding the infrastructure for economic growth with environmental and social responsibilities. Ultimately, the research demonstrates that achieving socially sustainable airport expansion is a dynamic process requiring ongoing dialog, adaptation, and a commitment to integrating realistic community needs into strategic decision-making.

Vienna Airport demonstrates a commendable commitment to social responsibility, with the majority of measures from the master plan being effectively implemented. These efforts position the airport as a strong example of best practices in socially responsible airport expansion. Many of the initiatives could serve as a benchmark for other airports undertaking similar projects. By addressing the recommended improvements, Vienna Airport has the potential to elevate its approach even further, transforming it into a true best-in-class case study. As it stands, the airport serves as a leading example, with slight adaptations required to fully align with the highest standards of social sustainability and stakeholder engagement.

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8 Appendix

8.1 Social management masterplan

8.1.1 IFC performance standards

PS1 is indispensable for creating a socially sustainable airport expansion master plan. Its focus on risk assessment, mitigation, and stakeholder engagement aligns directly with the goals of minimizing environmental and social impacts while fostering transparency and community trust. By integrating the principles of PS1 into the runway expansion framework, airports can address complex challenges holistically, ensuring compliance with international standards and promoting sustainable development.

Table 12. Environmental and social management systems based on PS1.

Measure	**Explanation**
Policy commitments	Develop clear policy commitments and ensure compliance with international standards that define the airport's approach to managing environmental and social risks, including specific actions on noise, displacement, and pollution (IFC, 2012a).
Risk identification	Identify social risks, such as increased noise levels, displacement, and community health impacts. Use the mitigation hierarchy to avoid, minimize, or offset residual impacts (IFC, 2012a; IFC, 2012b; IUCN, 2020).
Balanced approach to noise management – stated in EU regulation 598/2014	Apply ICAO's Balanced Approach principles: 1. Reduce noise at the source 2. Plan land use effectively 3. Implement noise abatement procedures 4. Apply operating restrictions (only as a last option) (ICAO, n.d.-b; IFC, 2007)
Noise and vibration management	Plan airport sites and routes to minimize noise in residential areas by implementing noise preferential routes and CDOs, and use sound barriers or deflectors where necessary. Limit nighttime flights during sensitive hours (IFC, 2007).
Collaboration with local Authorities	Work closely with local authorities to integrate safe land-use planning around the airport, reducing community exposure to risks like noise and air pollution (IFC, 2007).
Community and stakeholder engagement	Develop an engagement plan that fosters continuous dialog with affected populations. Ensure transparency and incorporate local input into decision-making, including planning for resettlement, livelihood restoration, and mitigation strategies. Build trust through meaningful consultations that address concerns about noise, land use, and other social impacts. Additionally, establish a culturally appropriate grievance mechanism to enable

	communities to provide feedback, including anonymously and ensure timely and transparent resolution of issues (IFC, 2012a; IFC, 2012c; IFC, 2007; ICAO, 2017; IUCN, 2020).
Community engagement	Conduct transparent consultations with affected communities and incorporate their preferences into decision-making, planning (resettlement and livelihood restoration), and mitigation strategies. Focus on building trust through responsiveness to community feedback by the grievance mechanism (IFC, 2012a; IFC, 2007; IFC, 2012c; IUCN, 2020).
Grievance mechanism	Establish a clear, accessible, and culturally appropriate grievance mechanism to address diverse community concerns. Include options for anonymous reporting to foster trust and broader participation and ensure timely and transparent resolution of issues (IFC, 2012c; IUCN, 2020; World Bank, 2018b).
Monitoring and reporting	Establish continuous monitoring systems to track the effectiveness of mitigation measures and *"identify evolving risks" (World Bank, 2018a, p. 3).* Share periodic reports with stakeholders and communities to proactively foster accountability and address evolving concerns (IFC, 2012a; IUCN, 2020).

Incorporating PS4 principles into the master plan for runway expansion ensures that community well-being is prioritized alongside operational goals. Addressing risks like noise pollution, these measures help build trust with local stakeholders and align the project with international sustainability and social responsibility standards. Applying PS4 mitigates potential conflicts and demonstrates a commitment to creating a socially sustainable airport expansion (IFC, 2012b).

Table 13. Community health, safety, and security based on PS4.

Measure	**Explanation**
Safe design and construction	Ensure that airport facilities, including runways, taxiways, and terminals, meet safety standards to minimize risks to nearby communities. Certify infrastructure safety (IFC, 2012b).
Operational safety management	Maintain Safety Management Systems that address operational risks like landings, takeoffs, runway maintenance, and obstacle-free zones (IFC, 2007).
Hazardous material management	Implement strict handling procedures and protocols for the safe storage, transport, and handling of hazardous materials, such as de-icing chemicals and fuel. Preventive measures are essential to protect local communities from exposure to toxic

	substances, which could lead to severe health issues (IFC, 2012b; IFC, 2007).
Stormwater and waste management	Ensure proper management of stormwater and waste to prevent contamination of local water supplies from de-icing chemicals or fuel spills. Contaminated water poses significant health risks to nearby communities, making effective collection and treatment systems vital for community health and safety (IFC, 2007).
Community health action plan	Development of specific action plans to address community health concerns, including monitoring for health impacts like stress or sleep disturbance from increased noise levels (IFC, 2012b).
Ecosystem and natural resource protection	Avoid and mitigate damage to ecosystems that protect communities, such as wetlands or buffer zones. Regarding Wildlife, focus on preventing bird strikes and managing other wildlife risks near airport properties. Control land use near airports and apply wildlife deterrent measures to reduce risks to aviation safety and community health (IFC, 2012b; IFC, 2007).

IFC PS5 provides a vital framework for managing land acquisition and involuntary resettlement during airport expansions. It ensures that adverse social impacts are minimized and that affected communities are treated equitably. PS5 addresses both physical and economic displacement, emphasizing fair compensation, livelihood restoration, and the development of comprehensive resettlement plans. These principles are essential for creating a socially sustainable master plan for constructing a new runway.

Table 14. Land acquisition and involuntary resettlement based on PS5.

Measure	**Explanation**
Avoidance and minimization of displacement	Prioritize runway placement and expansion plans that minimize the need for displacement. Conduct thorough evaluations to explore alternatives, reducing the social impacts associated with land acquisition (IFC, 2012c).
Compensation and livelihood restoration	Physical: Ensure communities and households displaced unavoidable by the project are compensated at full replacement cost for lost assets or housing. Go beyond monetary compensation by including livelihood restoration programs to ensure that displaced individuals achieve equal or improved living conditions (IFC, 2012c). Economic: Restore or enhance the income-earning potential of economically displaced individuals (IFC, 2012c) through job training programs, employment opportunities, or support for new business ventures.
Resettlement action plan and livelihood restoration plan	Develop comprehensive plans that outline strategies for relocation, provide relocation assistance, and identify

	development opportunities for displaced individuals or communities (IFC, 2012c).

8.1.2 ICAO community engagement measures

Effective community engagement is a cornerstone of socially sustainable airport expansion. Building trust with affected communities is essential for the success of any project. As the ICAO (2017) emphasizes,

"Community engagement, through open and transparent dialogue, can build trust and a willingness to collaborate," (ICAO, 2017, p. 1)

enabling stakeholders to address environmental challenges while pursuing sustainable growth. Engagement efforts must prioritize transparency, inclusivity, and responsiveness to integrate community concerns and successfully create a joint project effectively.

The ICAO outlines three core methods of community engagement—inform, involve, and collaborate—that form the foundation for meaningful interactions with local stakeholders (ICAO, 2017). These methods emphasize not only the dissemination of information but also the active participation of communities in decision-making processes. By adopting these principles, airports can mitigate resistance, foster trust, and ensure the social acceptability of new developments, such as runway expansions.

Table 15. Strategic engagement activities.

Measure	**Explanation**
Systematic approach	Develop a long-term engagement plan that identifies and aligns key community concerns with project goals. Differentiate between mandatory legal requirements and voluntary engagement efforts (ICAO, 2017).
Proactive and early engagement	Engage with stakeholders and communities before the project (as early as possible) begins to allow ample time for input and response. Early engagement prevents delays, builds trust, and minimizes resistance, ensuring smoother project implementation and reducing negative perceptions. Establish ongoing engagement even when no projects are planned (ICAO, 2017; World Bank, 2018b).
Tailored engagement	Customize engagement strategies to address the specific needs, concerns, and interests of each community, ensuring relevance and inclusivity (ICAO, 2017).
Transparency and trust building	Maintain open, transparent, and honest communication throughout the project, using simplified and accessible formats for all stakeholder groups. Transparency fosters understanding and inclusivity, enabling communities to engage meaningfully in the decision-making process. Building trust requires ongoing dialog with communities.

	Trust is reinforced when communities see tangible outcomes based on their input, demonstrating that their priorities are respected and acted upon (ICAO, 2017; World Bank, 2018b).
Expectation management	From the outset, manage expectations by acknowledging that not all concerns can be addressed to everyone's satisfaction. Clearly shows how community input has been incorporated into decisions to ensure stakeholders feel heard and respected (ICAO, 2017).
Collaboration	Work collaboratively with local governments, authorities, and communities to align project goals with community needs. A broad stakeholder base, including political and local leaders, ensures diverse input and helps to steer positive engagement (ICAO, 2017).
Evaluate engagement effectiveness	Measure the success and effectiveness of engagement using metrics such as the number of complaints or overall community satisfaction (ICAO, 2017).

Table 16. Technological approach.

Measure	**Explanation**
Modeling and visualization	Use tools like simulations and representations to explain and visualize complex changes such as airspace modifications, arrival/departure routes, and other operational adjustments. This helps communities better understand the impacts, fostering transparency and informed decision-making (ICAO, 2017).
Internet-based communication	Leverage digital channels such as emails, online surveys, and social media platforms to engage with affected communities. Social media, in particular, enables rapid and widespread communication, allowing organizations to gauge public sentiment and address concerns promptly and effectively (ICAO, 2017).

Table 17. Face-to-face meeting.

Measure	**Explanation**
Public meetings / announcements	Organize open forums to gather broad community input, provide project updates, and address general concerns. These meetings also help identify individuals for ongoing engagement and collaboration (ICAO, 2017).
Targeted meetings and working groups	Conduct focused discussions in smaller groups or committees to address specific issues, such as environmental or traffic impacts or operational hours. This approach allows in-depth problem-solving and tailored solutions (ICAO, 2017).

Table 18. Print and other media.

Measure	Explanation
Newspapers and newsletter	Traditional media is still effective for reaching out to communities. It can be used to broadcast information about airport projects or changes to a wide audience and is effective for one-way communication to ensure consistent messaging (ICAO, 2017).
Mail-outs	Target specific community members or stakeholders with direct communication. Provide updates, meeting invitations, or opportunities for input and approval (ICAO, 2017).
Document publication	Share detailed project reports, plans, or summaries in accessible, easy understandable formats to ensure transparency and foster trust within the community (ICAO, 2017).

Table 19. Community relationship building.

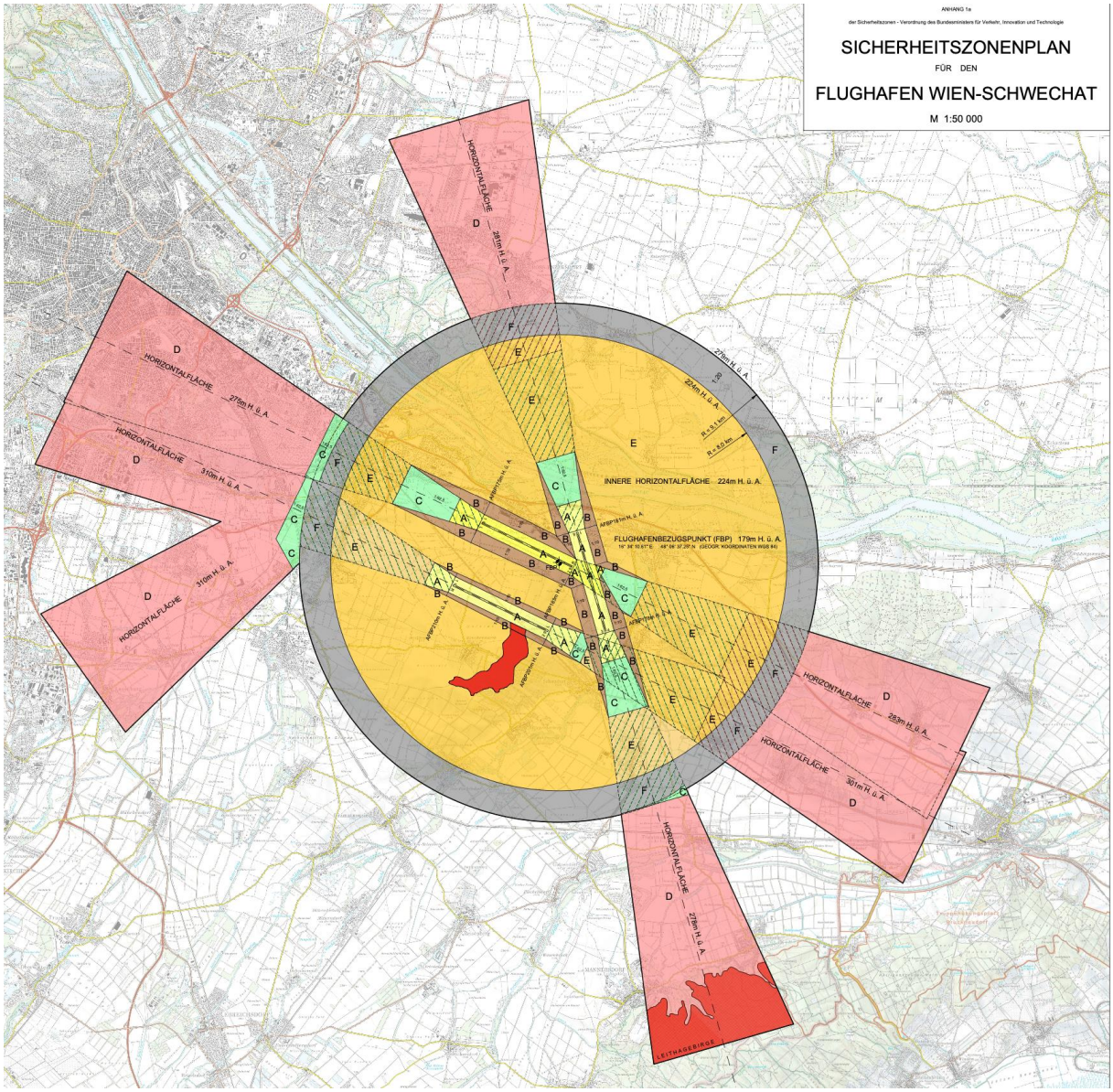
Measure	Explanation
Educational programs	Engage schools or local organizations to improve understanding of aviation operations and their effects (positive and negative), fostering awareness and cooperation (ICAO, 2017).
Others	Support local events, sponsor community activities, and organize educational trips to strengthen relationships, build goodwill, and integrate aviation into the community (ICAO, 2017).

The measures outlined by ICAO in the Airport Air Quality Manual emphasize a balanced approach to managing the environmental and social impacts of airport operations and expansions. These strategies, divided into operational, technical, and economic measures, aim to minimize noise, reduce emissions, and improve overall efficiency while addressing community concerns. Operational measures such as adjusting flight schedules and implementing CDO focus on immediate noise and emission reductions. Technical measures like high-speed runway exits enhance efficiency and reduce aircraft ground movement impacts. In contrast, economic measures like noise and emission-related charges incentivize airlines to adopt quieter and cleaner technologies. Together, these actions contribute to a more sustainable and socially acceptable airport expansion, aligning with the overarching goal of balancing growth with environmental and community well-being.

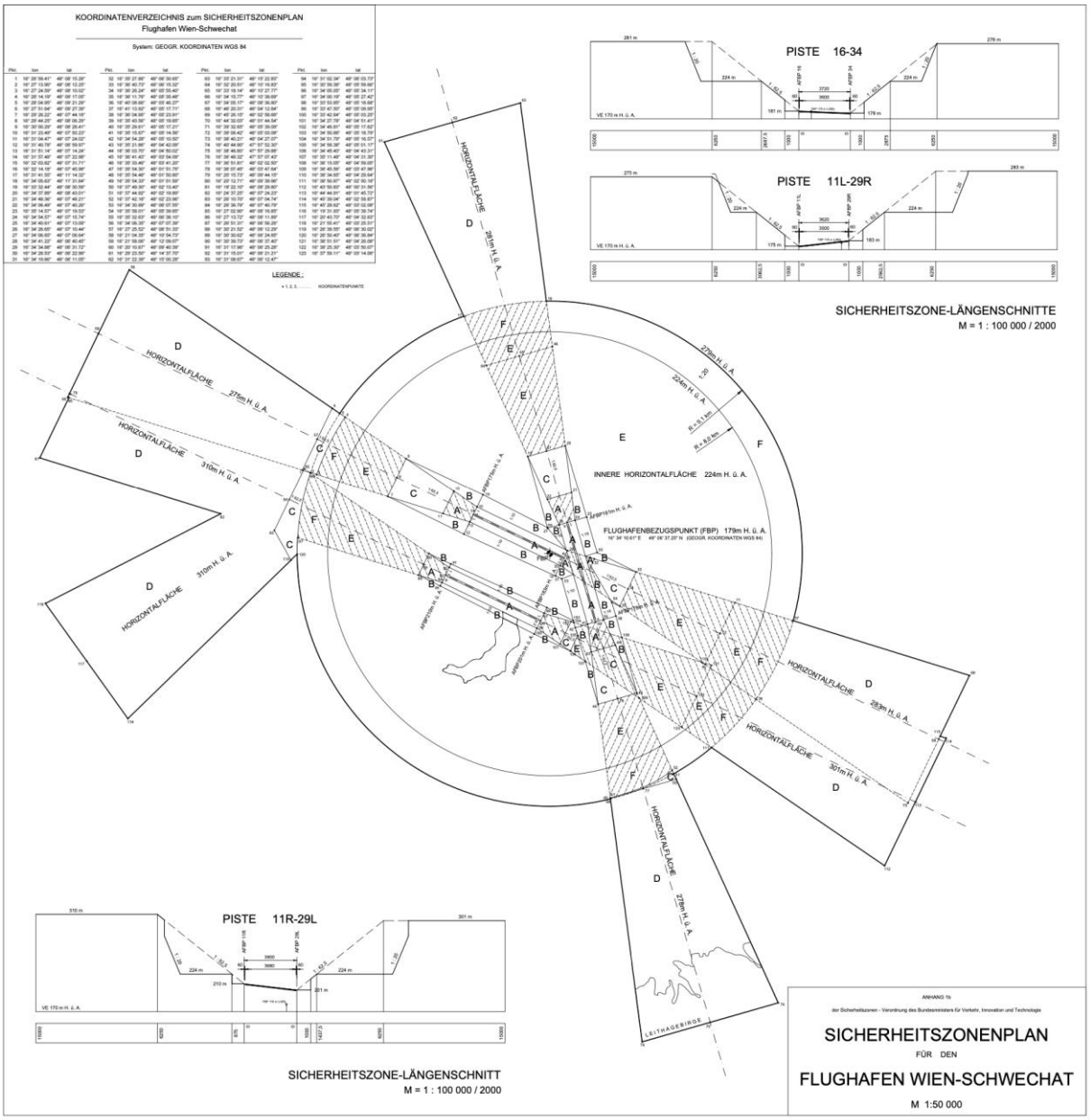
Table 20. Sustainability and climate change mitigation.

Operational measures	
Measure	**Explanation**
Adjusting schedule of airport and runways (ICAO, 2020)	Modify night curfews and operational hours of different runways to minimize environmental and social impacts and align with community preferences (e.g., reduce night flights).
CDO (ICAO, 2020) / climb operations, precise routing and clean configuration	Implement flight procedures that reduce noise and emissions by ensuring gradual CCO and CDO. Use precise Area Navigation and Standard Instrument Departures for better noise containment and maintain "clean configuration" during approach to minimize aerodynamic noise.
Single-engine taxi (ICAO, 2020)	Use only one engine for taxiing to reduce fuel consumption and emissions on the ground.
Longer distance aircraft towing (ICAO, 2020)	Tow aircraft over longer distances instead of taxiing under engine power to reduce fuel use and emissions.
Alternative jet fuels (ICAO, 2020)	Use SAF to decrease greenhouse gas emissions and environmental impact.
Technical Measures	
High speed runway exits (ICAO, 2020)	High-speed exits enable aircraft to vacate the runway more quickly, reducing runway occupancy time. This improves operational efficiency and contributes to noise reduction by decreasing idle times for departing and arriving aircraft.
Economic Measures	
Noise and emission related charges (ICAO, 2020)	Implementing charges based on noise and emission levels encourages airlines to use quieter and more environmentally friendly aircraft. These charges can incentivize modernization of fleets and adoption of sustainable practices, while generating funds for community and environmental programs.

8.2 Safety zone plan



Source: Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie, 2019



Source: Bundesministerium für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie, 2019