paranoá ORIGINAL ARTICLE
TECHNOLOGY, ENVIRONMENT, AND SUSTAINABILITY
2025
v.18, e48719

Land use and airport policies in Brazilian capitals: the case of Zumbi dos Palmares International Airport, Maceió/AL

Políticas de uso do solo e aeroportos em capitais brasileiras: o caso do Aeroporto Internacional Zumbi Dos Palmares, Maceió/AL

Uso del suelo y políticas aeroportuarias en capitales brasileñas: el caso del Aeropuerto Internacional Zumbi Dos Palmares, Maceió/AL

Stella Oliveira*
Universidade Federal de Alagoas; Faculdade de Arquitetura e Urbanismo; Programa de Pós-graduação em Arquitetura e Urbanismo.
Maceió (Alagoas), Brazil.
stella.oliveira@fau.ufal.br

Maria Lúcia Gondim da Rosa Oiticica
Universidade Federal de Alagoas; Faculdade de Arquitetura e Urbanismo; Programa de Pós-graduação em Arquitetura e Urbanismo.
Maceió (Alagoas), Brazil.

* Corresponding author.

CRediT

Author contributions: Conception; Data curation; Analysis; Data collection; Methodology; Validation; Visualization; Writing – original draft; Writing – review and editing: OLIVEIRA, S. Conception; Data curation; Analysis; Data collection; Methodology; Validation; Visualization; Writing – original draft; Writing – review and editing: OITICICA, M. L. G.R.

Conflicts of interest: The authors declare no competing or conflicting interests.

Funding: None.

Ethics approval: The authors certify that there was no need for Ethics Committee approval.

A.I.: The authors certify that no artificial intelligence was used in the preparation of the work.

Editors: Daniel Sant'Ana (Editor-in-Chief); Joara Cronemberger (Associate Editor); Rodrigues de Medeiros (Editorial assistant).

Submitted: 20 May 2023 | Accepted: 14 November 2024.

Abstract

In Brazil, research on the impact of aeronautical noise in urban areas near airports is still limited. To avoid the negative effects of aircraft noise, airports should be located away from urbanized areas. In this research, we investigate the possible influences of airports on the built environment and the interferences of air operations in city life. For this, data were collected on the acoustic approach in master plans and analysis of themes related to the development of airport infrastructure policies. We propose guidelines that aim to integrate airport development legislation with urban development policy. During the research process, we found the scarcity of acoustic approach in the legislations, even those updated regularly, and the lack of consideration to acoustic parameters.

Keywords: Acoustics; Environmental impacts; Master plan; Urban noise.

Resumo

No Brasil, as pesquisas sobre o impacto do ruído aeronáutico em áreas urbanas próximas a aeroportos ainda são limitadas. Para evitar os efeitos negativos do barulho dos aviões, os aeroportos devem ser localizados longe de áreas urbanizadas. Nesta pesquisa, investigamos as possíveis influências dos aeroportos no ambiente construído e as interferências das operações aéreas na vida nas cidades. Para isso, foram coletados dados sobre a abordagem acústica em planos diretores e análise das temáticas relacionadas ao desenvolvimento de políticas de infraestrutura aeroportuária. Foram propostas diretrizes que visam integrar a legislação de desenvolvimento aeroportuário com a política de desenvolvimento urbano. Durante o processo de pesquisa, constatamos a escassez de abordagem acústica nas legislações, mesmo nas atualizadas regularmente, e a falta de consideração aos parâmetros acústicos.

Palavras-Chave: Acústica; Impactos ambientais; Plano diretor; Ruído urbano.

Resumen

En Brasil, la investigación sobre el impacto del ruido aeronáutico en las zonas urbanas cercanas a los aeropuertos sigue siendo limitada. Para evitar los efectos negativos del ruido de las aeronaves, los aeropuertos deben estar ubicados lejos de las zonas urbanizadas. En esta investigación, investigamos las posibles influencias de los aeropuertos en el entorno construido y las interferencias de las operaciones aéreas en la vida de la ciudad. Para ello, se recogieron datos sobre el enfoque acústico en planes maestros y análisis de temas relacionados con el desarrollo de políticas de infraestructura aeroportuaria. Proponemos directrices que tienen como objetivo integrar la legislación de desarrollo aeroportuario con la política de desarrollo urbano. Durante el proceso de investigación, encontramos la escasez de enfoque acústico en las legislaciones, incluso las actualizadas regularmente, y la falta de consideración a los parámetros acústicos.

Palabras clave: Acústica; Impacto ambiental; Plan director; Ruido urbano.

1 Introduction

Brazilian urban infrastructure presents problems in relation to meeting its current demand. The set that makes up the transport system develops following directions resulting from the arrangements between its components, including the airport, with its surroundings marked by industrial and economic interests. In the view of Santos (2005), urbanization in Brazil refers to the translation of a social complexity that occurred in the face of the expansion of consumption, boosting relations with the territory, integrating them and creating an economic base, resulting in a new way of thinking about space.

Rech, Gullo and Scur (2019) argue that Brazil in the 21st century is experiencing the consequences of a lack of urban planning, expressed in many ways: compromised urban mobility, inefficient sanitation, air pollution and irregular occupation. The precarious conditions of urban mobility have been a torment for life in large Brazilian cities. Economic incentives for the population to purchase cars, combined with the low quality and lack of safety in public transport modes, have led to a dramatic increase in the car fleet in Brazil.

The demand for transportation, of people or goods, cannot be fully met by any single mode of transport. Transportation modes have advantages and disadvantages in light of issues that are interrelated and affect demand conditions, such as: characteristics of cities, such as topography, climate and culture; types and quantities of goods that vary according to the structure of each city or region and are influenced by the country's position in the global market; traffic intensity that can be met in the present and future; income and consumption patterns of the population and distances to be traveled (Cappa, 2013).

Souza (2013) argues that the most common type of zoning is linked to land use. In this type of zoning, the city is divided into zones according to the type of land use most appropriate for the different parts of the urban fabric. For example, it makes no sense to foresee or approve the location of polluting industries and enterprises in a residential area; this would be a blatant threat to the health and well-being of residents.

According to the Brazilian Civil Aviation Regulations, defined by RBAC 161 (ANAC, 2011), after registering the Noise Zoning Plan with the National Civil Aviation Agency, the aerodrome operator must seek actions to make land use compatible with the municipality(ies) covered by the noise curves, as well as with the surrounding community, notifying ANAC, the municipalities and interested bodies whenever uses incompatible with the approved PZRs are identified.

In Maceió, Lins, Almeida and Oiticica (2016) carried out a survey of residual noise 1in the vicinity of Zumbi dos Palmares International Airport. The results obtained show that when there is no aircraft passing by, the sound pressure level is 47 dB LAeq and 55 dB maximum LAeq, while with the passage of a Piper Aircraft PA-34-220T aircraft, the sound pressure levels reach 74 dB LAeq and 82 dB maximum LAeq. The scenario with the passage of an Airbus Industrie A321-111 presents sound pressure levels of 85 dB for LAeq and 94 dB for maximum LAeq.

These data demonstrate that the passage of aircraft over the region causes a noise disturbance capable of reaching levels well above what is considered acceptable by NBR

[1] That which remains after other sources of noise have been reduced or eliminated. It can be caused by sound reflections, vibrations, resonances and other acoustic phenomena.

10151 (ABNT, 2019). It is observed that in the case of measurement 2, the LAeq exceeds the recommended Sound Pressure Level by 19 dB, reaching, in the worst case situation, corresponding to the maximum LAeq result, an increase of 27 dB(A). The results of measurement 3 demonstrated an even greater noise disturbance, with the difference between the recommended and measured LAeq being 30 dB, and being able to reach a value of up to 39 dB (Lins; Almeida; Oiticica, 2016).

The acoustic data from the survey by Lins, Almeida and Oiticica (2016) were used as a parameter for characterizing the sound of the study to support the data obtained in situ, when relevant for their use in the research. Therefore, this work aims to present guidelines that help connect the instruments of development policy with those of airport infrastructure, with a view to Zumbi dos Palmares International Airport, to assist in controlling the impact of airport noise.

1.1 Cities and their Airports

Airports located far from urban centers become vectors for the expansion of the city. This occurs due to the need to promote quality urban infrastructures such as: roads, water, sewage, and energy to the airport (Garcia, 2015).

Romaro (2007) states that the new configuration of airports, resulting from growth and structural changes, led to the development of "airport cities", true intermodal transport hubs.

Airports are now intensifying the economic transformation of the outskirts of the metropolitan areas in which they are located. The exceptional accessibility of airports attracts other activities. In addition, they tend to attract activities that were previously the monopoly of traditional city centers.

According to Romaro (2007), the result of this process, in which the airport represents one of the main drivers of decentralization, is that the growth rate of these peripheral areas close to this facility is much faster than in the centers. This means that the airport acquires a new and enormous importance on a regional scale.

The development of Brazilian air transport is deeply linked to economic policies and government interventions. Government decision-making on the economy and exchange rates are factors that, depending on the combination, can lead to maximum competition between companies or a cooling of the market (Kaiser, 2012).

According to Kaiser (2012), it is possible to observe over the last 30 years that different political moments have actively interfered in the development of the airline industry. In the 1970s, still under strong military influence, we observed a moment of intense regulation in the economic and industrial sphere.

According to the National Development Bank (BNDES, 2010), the airline industry was officially redistributed into regional and national companies. The country was divided into five macro-regions where the companies would operate under a monopoly regime and with specific markets. Flight prices and tickets were controlled by industry authorities, and new companies were prohibited from entering the market. The 1980s brought intense political changes, and the country began to experience a period of opening up and macroeconomic problems.

With rampant inflation and the need for control, all attention turned to stabilization plans that ended up being intrusive to the productive sectors of the economy. In addition, the devaluation of the exchange rate increased the costs of inputs. The development of Brazilian air transport is deeply linked to economic policies and government interventions. Government decision-making on the economy and exchange rates are factors that, depending on the combination, can reflect maximum competition between companies or a cooling of the market (BNDES, 2010).

According to Kaiser (2012), over the last 30 years, it has been possible to observe distinct political moments that actively interfered in the development of the airline industry. In the 1970s, still under strong military influence, we observed a moment of intense regulation in the economic and industrial sphere.

To select the cities under study, some aspects were taken into consideration, such as: location and proximity to city centers, population, area, airport capacity, year of implementation.

The cities analyzed from the point of view of their airports were: São Paulo/SP, Rio de Janeiro/RJ, Recife/PE, Porto Alegre/RS, Fortaleza/CE and Brasília/DF, identified in Figure 1.

Figure 1: Map of Brazil with demarcation of the Brazilian states defined for study.

Table 1 presents pertinent data regarding the cities chosen for the development of the work, such as: area, population of the city where the airport is located, distance to the Center, year of implementation of the airport, and capacity.

Table 1: Data relating to the cities selected for the Repertoire Study.

City/ Airport	Year of implementation	Population (2020)	Area (km^2)	Distance to Center (km)	Passengers in 2019 (millions)	Passenger capacity
Sao Paulo (Congonhas)	1936	12.33	1,521	8	22,281,896	1.6 million
Rio de Janeiro (Santos Dumont)	1938	6.74	1,255	0	8,933,777	9.9 million
Brasilia (Juscelino Kubitschek)	1956	3.05	5.802	12	19,821,796	21 million
Recife (Gilberto Freyre)	1958	1.65	218	11	8,531,312	16.5 million
Porto Alegre (Salgado Filho)	1940	1,488	496.8	9	8,292,608	16.5 million
Fortress (Pinto Martins)	1966	1,488	496.8	9	7,218,697	13.5 million
Manaus (Eduardo Gomes)	1976	2,219	11.401	14	7,218,697	12.5 million

Table 2 presents the chronology of master plans implemented in each city for the selected airports from the decade in which they came into force, in order to verify the evolution of this urban tool in each city.

Table 2: Selected cities and their Master Plans, 1950-2020.

City	1950/1960	1970	1980	1990	2000	2010	2020
Rio de Janeiro/RJ	Doxiadis Plan, 1965 *(1)*			Law No. 16/1992		Law No. 111/2011	
São Paulo/SP		Law No. 7,688/1971			Law No. 13,430/2002	Law No. 16,050/2014	Revision
Recife/PE				Law No. 15,547/1991		Law No. 17,511/2008	Revision
Porto Alegre/RS	Law No. 2,046/1959 *(3)*	Law No. 43/1979		Law No. 43/1999		Law No. 646/2010 *(6)*	Revision
Fortaleza/CE	Law No. 2,128/1963	Law No. 7,122/1979(4)		PDDU-FOR (1992)	Law No. 062/2009		
Manaus/AM	Law No. 1,033/1968				Law No. 671/2002	Law No. 2/2014	
Brasília/DF	Pilot Plan 1957	PEOT 1977	POT 1985	PDOT 1997	PDOT 2009		

The Master Plan is defined as the main tool for spatial development, and the importance of the articulation between urban planning and airport planning considered in its legal instruments is clear. The question that remains is whether this relationship is effectively included in the planning process.

Noise pollution, which is one of the most vehemently questioned environmental issues in cities, is directly related to the types of transport noise, which have already been explained previously, with its aspects of interest necessarily being correlated not only with urban dynamics but also with regulations currently in force that sometimes do not even mention their effects in the urban context.

2 Method

The work consists of an investigation into the compatibility of the master plan and land use and occupation laws of the municipalities of Maceió and Rio Largo, where the Zumbi dos Palmares International Airport is located on the border between the two (Figure 2).

Figure 2: Map diagram of Brazil highlighting the state of Alagoas, Alagoas highlighting the municipalities of Maceió and Rio Largo, and Maceió.

Data relating to the geometric and morphological characteristics surrounding the object of study were collected through cadastral maps (provided by the Municipality of Maceió), Google Earth®, as well as *"in loco"* visits.

The information collected refers to physical characteristics such as: width of roads and sidewalks and topography, building height, road paving, land use and occupation, wall height and distance between buildings.

Master Plans of some Brazilian cities were investigated, with an acoustic approach present in these Laws. The cities (capitals) selected were: Rio de Janeiro - RJ, São Paulo - SP, Recife - PE, Fortaleza-CE, Manaus - AM, Porto Alegre - RS and Brasília - DF.

The cities were chosen based on relevant content regarding the urban context of the airports in these cities. This material will serve as a basis for developing acoustic guidelines for the review of the Master Plans for the cities of Maceió and Rio Largo. The examples will serve as inspiration for the proposed guidelines that were formulated considering the local context.

This methodological stage will also consist of investigating and identifying the approach to acoustics in Maceió's master plan. 2005. The main purpose of this stage will be to analyze the themes that address acoustic issues, in order to, from this analysis, propose guidelines and prepare the contribution letter for the review of the Master Plan in relation to the airport.

A bibliographic survey of municipal laws regarding noise levels in urban areas was then carried out, with emphasis on the sounds produced by Zumbi dos Palmares International Airport (Table 2).

After the documentary review and identification of acoustic approaches aimed at the Master Plans of the cities of Rio Largo and Maceió, the guidelines were also drawn up considering the local context. To create parameters for comparing the data collected in the

study, it was necessary to provide an overview of existing Brazilian regulations and municipal legislation.

Table 2: Municipal legislation and Brazilian regulations on urban acoustics and noise pollution.

Legislation	Brazilian standardization
Master Plan of Maceió/2005	NBR 10151 (2019) – Noise Assessment in Inhabited Areas Aiming at Community Comfort
Maceió Urban Planning Code/2006	
Rio Largo Master Plan /2009	
Rio Largo Urban Planning Code/1997	
Law 3,538 - Recommendations for controlling environmental pollution, including noise pollution/1985	
Law 4,956 - Regulates the operation of commercial establishments/2000	

3 Analysis of results

The analyses and diagnosis of the repertoire study will be presented based on the acoustic recommendations obtained in master plans of Brazilian cities, in order to relate the pertinent data for integration into the master plan of the cities of Maceió and Rio Largo and the Zumbi dos Palmares International Airport.

Located 20 km from the bus station and 22 km from the city center of Maceió, it is accessed via the BR- highway 104, a, which connects the states of Pernambuco to Alagoas. From Maceió, access is via the main roads: Avenida Durval de Góes Monteiro and Avenida Menino Marcelo, as shown in figure 3.

Figure 3: Location of Zumbi dos Palmares International Airport and its immediate surroundings.

Source: Adapted maps (2022).

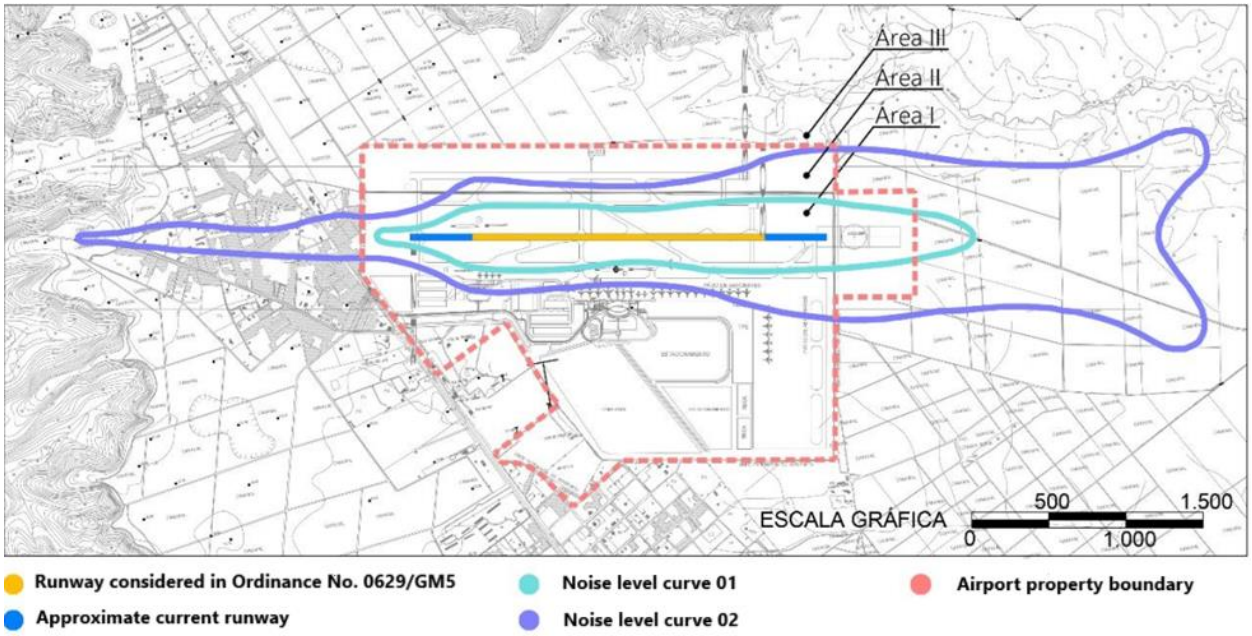
In the consultations carried out at the Airport Development Superintendence of the cities of Rio Largo and Maceió, it was found that the noise plan currently used by Zumbi dos Palmares Airport is still the one defined by Ordinance No. 692/1984. Based on this information and the knowledge that the length of the runway at Maceió airport has increased, it can be considered that the current PEZR should not meet the parameters currently considered by Regulation No. 161/2013, meaning that the people who occupy the airport's surroundings will be the ones most affected by this situation.

In 2005, the new Zumbi dos Palmares airport was built in an area disputed by the municipalities of Maceió and Rio Largo, resulting in a division of state taxes.

In the demarcation of limits referenced by IBGE in 2010, the outline of the old airport appears – Campo dos Palmares, located in the municipality of Rio Largo/Alagoas, but its area of influence also covers the municipality of Maceió.

The Rio Largo Building and Construction Code was established in 1997, by Law No. 1,208. It does not address any specifications or restrictions on buildings in the area surrounding Zumbi dos Palmares airport.

Figure 4: Location plan of Zumbi dos Palmares International Airport superimposed by noise level curves 01 and 02 of ordinance no. 629/1984.



Source: Ordinance No. 629/1984. Ministry of Aeronautics (1984).

The Master Plan for the city of Maceió was drawn up in 2005, citing the area surrounding the airport in three main points:

a. Restricting verticalization in the airport's visibility cone area, by controlling the height of buildings close to the airport;

b. The need to monitor urban growth around the airport, given the area's proximity to the Pratagy system – water collection and treatment station; and

c. The possibility of installing social housing and implementing commercial and service hubs close to the airport, as long as they are in line with the area's restrictions.

Figure 4 illustrates the difference in runway length between the 1984 period and that defined by the 2005 renovation project. In the image, it is also possible to see noise level curves 01 and 02 of Ordinance No. 629/1984.

4 Acoustic analysis of the Master Plans of Brazilian cities

For analysis purposes, the results were summarized in Table 3 to facilitate analysis and support the proposed guidelines. To this end, a survey was prepared and a selection of municipal Master Plans were analyzed for Brazilian cities in the period 1950-2020.

Table 3: Sound integration guidelines in master plans of Brazilian cities.

City	Acoustic approach	Guidelines
São Paulo	Installment use and land occupation and the urban landscape	1. A strategy for controlling atmospheric noise pollution must be presented. 2. Uses and activities will be classified according to the impact they cause on each other, namely noise impact. 3. The Neighborhood Impact Study must present the generation of environmental and noise pollution in the area (São Paulo, 2014).
	Environmental Policy	4. The aim is to combat noise pollution (São Paulo, 2014).
	Mobility	5. Encourage the renewal or adaptation of vehicles with the aim of reducing environmental and noise pollution; electric-powered motor vehicles are recommended. 6. For public transport, environmentally and technologically appropriate solutions are encouraged, which provide minimum noise levels (São Paulo, 2014).
Rio de Janeiro	Environmental Policy	1. Environmental control, monitoring and inspection of air, water, noise, soil and subsoil pollution, environmental liabilities, solid waste and visual pollution (Rio de Janeiro, 2011).
	Neighborhood Impact	2. The Neighborhood Impact Report (RIV) is applied to projects that result in a substantial increase in the circulation of people and vehicle traffic, or in massive use of infrastructure, or even in those that cause environmental discomfort to the population, such as liquid, solid or noise emissions or conditions that imply low air circulation capacity, among others, in order to assess the scope and importance of the impacts and adapt, if necessary, the project to the physical and environmental capacity of the region (Rio de Janeiro, 2011).
	Environmental Control and Monitoring	3. The community against noise pollution and vibrations from industrial, commercial activities (Rio de Janeiro, 2011), shows, tournaments and recreational activities that may interfere with public peace (Rio de Janeiro, 2011).
Recife	Use and occupation of the soil	1. Art. 13. Specific Guidelines Zones - ZDE - comprise areas that require special treatment in the definition of regulatory parameters for land use and occupation and are classified as: V - Special Airport Zone - ZEA; and Art. 25. A Special Airport Zone - ZEA - comprises the areas surrounding Guararapes Airport that require differentiated treatment regarding their occupation and installation of uses, aiming to contain population density and compatibility with the specific Federal Law of the area (Recife, 2008).
Fortaleza	Policy of Environment	1. Encourage the reduction of environmental pollution levels, including noise pollution. 2. To control environmental quality, the municipal policy for the control and licensing of environmental pollution, including noise pollution, must be defined. 3. Promote actions to reduce the levels of pollutant and noise emissions caused by motor vehicles (Fortaleza, 2009).
	Use and occupation of the soil	4. Noise pollution should be taken into account when analyzing the level of discomfort of projects generating impacts. 5. The Neighborhood Impact Study must contain analyses and recommendations on the generation of pollution, including noise pollution. 6. In Special Institutional Zones (ZEI), the approach cones and the special airport area must follow the Land Use and Occupation Law due to noise (Fortaleza, 2009).
Porto Alegre	Urban Impact	1. Environmental goods, with regard to the quality of air, soil and subsoil, water, flora, fauna, and visual and noise pollution resulting from the activity (Porto Alegre, 2011).
Brasilia	Environment	1. Adopt environmental education and control measures, avoiding all forms of pollution and environmental degradation in the territory.
	Transport Policy	2. Promote environmental quality, achieved by controlling pollution levels and protecting historical and architectural heritage (Brasília, 2009).

City	Acoustic approach	Guidelines
Manaus	Establishments of Meetings and Entertainment Use and Occupation of the soil	1. Using sound devices, amplifiers and similar equipment that produce noise in violation of the Manaus Environmental Code (Manaus, 2014). 2. Assessment parameters for noise pollution (decibels): group 1: >30, group 2: 59, group 3: 74, group 4: 85, group 5: 85< (Manaus, 2014).

It can be seen that in the Master Plans investigated, the issue of acoustics is discussed in several premises of the Law. The main focus is noise pollution and combating aviation noise. The topics present variations in nomenclature from one city to another, but they address similar aspects. Since 2015, Maceió's Master Plan has been under review and, to date, it has not yet been considered for publication.

It is noted that acoustic aspects are addressed in only one of the premises of the master plan, in the urban and environmental control instruments. Within this theme, the acoustic approach is noted in the Law on the Neighborhood Impact Study (EIV), which indicates noise pollution as a prerequisite for the EIV.

When compared to the Master Plans presented in the document review, a scarce approach to acoustic aspects is noted, since only one premise mentions it. Other fundamental themes for noise control, such as urban mobility and the environment, are not addressed.

Regarding the determination in the Master Plan of the City of Maceió, curve B, used to measure sound data related to vehicle traffic in the city, is not frequently used for this type of study, since its objective is to verify the impact of noise on the inhabitants of the region, therefore, curve A, which is closest to the human ear, is indicated.

Regarding the current laws of the city of Rio Largo, both the Urban Planning and Building Code and the first Master Plan were instituted prior to the implementation of the airport. Regarding the city of Rio Largo, the current master plan dates back to 2009, and mentions noise pollution in six sections and Zumbi dos Palmares International Airport in one.

4.1 Proposals and Recommendations

Considering the context of Zumbi dos Palmares Airport, acoustic proposals and guidelines were formulated to contribute to the process of reviewing the Master Plans of the cities that govern its territory. The guidelines were prepared according to the theme and presented in Table 4.

Table 4: Sound integration guidelines presented to Zumbi dos Palmares International Airport .

Theme	Responsible	Guideline
Land use and occupation	**Airport**	1. Submission of the Noise Zoning Plan every 10 years to combat noise pollution related to aircraft. Recommended for a period similar to that of review of Master Plans.
	Public Actions	1. Presentation of strategies to control atmospheric noise pollution produced by the airport. 2. The uses and activities developed by the airport will be classified according to the impact they cause, with noise zones being identified, as per the current Noise Zoning Plan.

		3. Activities that cause negative repercussions are subject to the adoption of mitigating measures, one of which is the implementation of noise control and vibration attenuation measures, such as acoustic and vibration insulation, confinement or relocation of equipment and noisy operations. 4. For the vicinity of the airport, procedures for assessing urban sound pressure levels must be applied, with 55 dB(A) recommended for predominantly residential mixed areas during the day and 50 dB(A) at night, based on NBR 10151: Acoustics - Assessment of noise in inhabited areas, aiming at community comfort (ABNT, 2019). 5. Construction of the Specific Guidelines Zone - ZDE - includes areas that require special treatment in the definition of regulatory parameters for the use and occupation of land around the airport and are classified as:
Environmental Impact Study	**Airport**	1. I - Special Airport Zone - ZEA; Which comprises the areas surrounding Zumbi dos Palmares Airport that require differentiated treatment regarding their occupation and installation of uses, aiming to contain population density and compatibility with the specific Federal Law of the area. Based on NBR 12859 (ABNT, 2016) which deals with the Assessment of the noise impact generated by aeronautical operations. 2. Restructure: Present a new Noise Zoning Plan in order to have greater restrictions among the contour lines in the Special Noise Plan to obtain greater distance from inhabited areas and the airport.
Environmental control and monitoring	**Public Actions**	1. From the community: diagnose aeronautical noise and vibrations from airport activities that may interfere with public peace. 2. Encourage: use of acoustic barriers for highways and porous asphalt as well as the use of elements that absorb urban noise, such as vegetation masses and construction materials that promote noise control and/or reduction.
	Airport	3. Programming: Changing flight routes, especially in rural areas, using the sound mapping tool to understand the routes that least affect public health. 4. Implement: Limitation of flight times, with times between 22:00h and 05:00h being recommended for limitation as they are convenient for the peace and quiet of the affected populations.
Mobility	**Public Actions**	1. Promote environmental quality, achieved by controlling aeronautical noise levels and protecting historical and architectural heritage. 2. Create a sound map of the city containing the spatial distribution of noise, to assist in the management of environmental noise and the noise impact caused by flights carried out during the day and night (landing and take-off to monitor flight routes). 3. Establish a standard for quality and monitoring of data and mapping of urban noise.
Acoustic performance	**Public Actions**	1. Application of the recommendations of NBR 15575-4 (ABNT, 2013), with acoustic requirements to be met such as: 2. Flooring systems: insulation against airborne noise and impact noise between different apartments; 3. Facades, roofs and internal walls: airborne noise insulation of facades and roofs, as well as internal walls separating different apartments. 4. Use of construction materials with sound absorption and insulation properties, reorganization of the layout of rooms – the most sensitive areas, such as bedrooms, should be kept away from noisy places.

		5. Airborne and impact noise insulation measurements when relevant to the application based on recommended standards and respecting the sound reduction indexes of facades and internal seals in the composition of these buildings.
Environment	**Public Actions**	1. The aim is to combat the aeronautical noise produced by Zumbi dos Palmares Airport. 2. Combat noise pollution produced by Zumbi dos Palmares Airport by representing a strategic noise map based on the path of aircraft during landing and takeoff. 3. Promote the study of aircraft noise management to contribute to ensuring quality of life in social and environmental aspects. 4. Monitor urban aspects taking into account the radius defined by ANAC, as set out in Ordinance 1,141 GM5 (1987) to promote quality of life around airports. 5. Promote acoustic comfort in the vicinity of Zumbi dos Palmares Airport through public actions in partnership with non-governmental organizations, companies and society. 6. Environmental Education: Implement a community sound education program with an emphasis on studying the impact of aircraft noise, with the aim of contributing to the knowledge and improvement of the quality of sounds produced by Zumbi dos Palmares Airport. 7. To control environmental quality in the areas surrounding Zumbi dos Palmares Airport, the municipal policy for controlling and licensing noise pollution must be defined.

In the area of land use and occupation, the use of the building must be classified to verify the noise impacts on the surrounding area and the amount of impact from aeronautical noise that the building will be exposed to in order to predict the necessary acoustic performance for this building.

For acoustic measurement procedures in the community, it is recommended to follow Standard 10151 (ABNT, 2020), which establishes the maximum sound pressure levels according to the shift and type of use of the area. Specific Zoning includes areas that require special treatment in the definition of regulatory parameters, with the indication of the Specific Guidelines Zone and Special Airport Zone - ZEA, which are linked in addition to NBR 12859 (ABNT, 2016), which deals with the Assessment of the noise impact generated by aeronautical operations.

The application of the ZEA is based on the monitoring and definition of factors that specify the permitted sound levels, as well as the demands for use and occupation of the specific land for the radius defined by ANAC and specified in Ordinance 1,141 GM5 (1987), as well as requirements that deal with the minimum conditions necessary for the proper acoustic treatment of buildings.

In the Environmental Impact Study instrument, it is suggested that aircraft noise be kept as an aspect to be carried out. It is recommended that the EIA present the generation of noise pollution caused by the airport, an aircraft noise map of environmental impacts and the main areas affected so that measures can be taken to mitigate this impact, such as replacing prerequisites for housing, such as: frames in the surrounding residences aiming at acoustic insulation.

In terms of the environment, studies on aircraft noise in the city are encouraged to raise awareness about the acoustic quality of the urban environment. The guidelines suggest partnerships between the public and private sectors and investments in sound education, as a measure to improve critical thinking about the sounds that people want to hear.

The theme of Environmental Control and Monitoring raises concerns about the effects of aeronautical noise and its interference with public peace. In addition to encouraging the use of acoustic barriers and the implementation of efficient acoustic treatment for urban areas, as well as the implementation of vegetative masses and construction materials that

promote noise control and/or reduction, depending on the implementation and quantification.

Based on the premise of urban mobility, environmental quality is encouraged, which is achieved by controlling aeronautical noise levels, since aircraft are one of the main sources of urban noise. Measures such as the use of acoustic barriers (Bistafa, 2011), porous asphalt, and the development of sound mapping are proposed in order to obtain the spatial distribution of noise to aid environmental management. It is also recommended that a quality and data monitoring standard be adopted, so that the city's sound map is updated periodically.

The municipality's acoustic capacity map is an urban planning tool that determines the noise limits for each part of the city and limits the implementation of noisy activities, above the standard limit, and may also restrict residential developments in noisy areas and provide for an acoustic Environmental Impact Study for the developments.

5 Final remarks

Due to the harmful effects caused by aircraft operation, which causes aircraft noise, there is a general consensus in the literature that airports should be located in areas far from cities and mainly in areas that are used for residential purposes and/or require silence. In some cases, cities develop towards airports due to the infrastructure and economy generated by urban expansion in the area.

It is worth noting that the work presents an approach of more generalist proposals and recommendations that are justified due to the macro scale of the study area, not being an object of study with definable limits, but rather dealing with a large inhabited area between the limits of two medium-sized cities.

The study proposed the application of a comparative analysis of data obtained from legislation, making the master plans of the selected cities compatible with the land use and occupation laws of the municipalities of Maceió and Rio Largo in relation to Zumbi dos Palmares Airport, based on the investigation of the influences of the airport on the built space and the mutual interference between air operations and conflicts in the cities.

In summary of the analyses carried out through the survey of urban legislation, it is possible to identify in the Master Plans investigated that the theme of acoustics is discussed in several premises of the Laws addressed. The main focus is on noise pollution and the fight against aircraft noise, presenting themes with variations in nomenclature from one legislation to another, but addressing similar aspects of the law. Some of these themes are interconnected, as is the case of the Master Plan of the city of Fortaleza, which deals with noise caused by motor vehicles in the section on the environment. These acoustic approaches are mainly addressed in: land use and occupation, urban mobility, environment and political-social.

It is clear that despite its importance in combating and prior management of aeronautical noise in areas of possible impact, many of the laws still do not address the Neighborhood Impact Study - EIV as a control tool, allowing us to address and understand impacts linked to environmental pollution that the project to be implemented will have.

In the case of the area surrounding Maceió International Airport, urban occupation has occurred in recent decades and is still in the consolidation phase, with an increase in the number of housing developments. Another key factor in the construction of this work was the analysis of the recommendations addressed in the master plans of the cities of Maceió and Rio Largo, since the master plan for the city of Rio Largo only deals with adopting measures to attract tourists to the airport, thus exposing the interest in taking advantage of its location and potential.

Also noteworthy is the approach to Development Potential, which will depend on the preparation of a Preliminary Neighborhood Impact Study and respective Neighborhood Impact Report to obtain a license or authorization for subdivision and construction – thus demonstrating the interest in applying the use of this tool for future large-scale projects.

It is understood that the simple elaboration of the law that institutes a Master Plan does not lead to the expected results for cities, with the first challenge being to structure an Urban Development sector that brings together inspection and planning so that the advocated recommendations are applied.

This work aims to contribute to the development of recommendations, in order to assist in the connection between airport and public management, based on the survey of urban legislation, to assist in controlling the impact of airport noise with the construction of integration proposals as urban instruments for application in the legislation analyzed.

Acknowledgements

This work is grateful for the support of the Alagoas State Research Support Foundation (FAPEAL) for the scholarships granted to the Postgraduate Program in Architecture and Urbanism (PPGAU/UFAL).

References

ABNT – ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNICAS. **NBR 10151**: Acústica - Medição e avaliação dos níveis de pressão sonora em áreas habitadas - Aplicação de uso geral aplicação de uso geral. Rio de Janeiro: ABNT, 2019. 24 p.

ANAC – AGÊNCIA NACIONAL DE AVIAÇÃO CIVIL. REGULAMENTO BRASILEIRO DA AVIAÇÃO CIVIL. **ANAC RBAC 161**: Planos de zoneamento de ruído, aprovado pela Resolução nº 202 de 28 de setembro de 2011. 25p.

BNDES – BANCO NACIONAL DE DESENVOLVIMENTO. **Estudo do Setor de Transporte Aéreo do Brasil: Relatório Consolidado**. Rio de Janeiro: McKinsey & Company, 2010.

CAPPA, J. **Cidades e aeroportos no século XXI**. Campinas: Alínea, 2013.

FORTALEZA. **Lei Nº 8097**. Dispõe sobre medidas de combate à poluição sonora e dá outras providências. Fortaleza, 1997. Disponível em: https://urbanismoemeioambiente.fortaleza.ce.gov.br/images/urbanismo-e-meioambiente/catalogodeservico/lei_municipal_no_8.097_97__lei_de_combate_a_poluicao_sonora.pdf. Acesso em: 18 maio 2023.

GARCIA, O. F. **O aeroporto de Congonhas e a cidade de São Paulo: Uma história de afinidade e conflitos**. Dissertação (Mestrado) Pontifica Universidade Católica de São Paulo – PUCSP. Faculdade de Geografia. São Paulo. 2015.

KAISER R. **Impacto de NLAS para o sistema de desembarque do TPS 1 do aeroporto internacional do Rio de Janeiro (GALEÃO)**. Dissertação (Mestrado) Pós-graduação em Engenharia de Produção – COPPE. Rio de Janeiro – RJ. 2012.

LINS, D. L. D. M. S. ALMEIDA, J. D. E. S. OITICICA, M. L. G. D. R. **Avaliação do ruído no entorno de aeroportos estudo de caso**: o Aeroporto Internacional Zumbi dos Palmares- Maceió-AL.7º Congresso Luso Brasileiro para o Planejamento Urbano, Regional, Integrado e Sustentável: Contrastes, Contradições e Complexidades, Maceió-Brasil, 20216.

MANAUS. **Plano Diretor Urbano e Ambiental de Manaus e suas Leis Complementares**. 2014. Disponível em: https://implurb.manaus.am.gov.br/legislacao/. Acesso em: 18 maio 2023.

PREFEITURA DA CIDADE DE RECIFE. **LEI 7.427**: Dispõe sobre as vizinhanças dos aeroportos, observando o que dispõe a legislação federal, sobre a proteção. 1961.

PREFEITURA DA CIDADE DE RECIFE. **Lei nº 17.511** - Promove a revisão do Plano Diretor do Município do Recife. 2008.

PREFEITURA DA CIDADE DO RIO DE JANEIRO. **Lei complementar nº 198**. 2019.

PREFEITURA DA CIDADE DO RIO DE JANEIRO. Plano Diretor do município do Rio de Janeiro - **Lei Complementar n.º 111**. Rio de Janeiro. 2011.

PREFEITURA MUNICIPAL DE MACEIÓ. Plano Diretor do município de Maceió - Lei Municipal nº 5486. Maceió. 2005. Disponível em: https://www.sedet.maceio.al.gov.br/servicos/plano_diretor. Acessos em: 18 maio 2023.

PREFEITO MUNICIPAL DE PORTO ALEGRE. Plano Diretor do Município de Porto Alegre - **Lei Complementar nº 434**, de 1º de dezembro de 1999, atualizada e compilada até a Lei Complementar nº 667, de 3 de janeiro de 2011, incluindo a Lei Complementar 646, de 22 de julho de 2010.

PREFEITURA DA CIDADE DE RECIFE. **Lei nº 17.511** - Promove a revisão do Plano Diretor do Município do Recife. 2008.

PREFEITURA DA CIDADE DO RIO DE JANEIRO. **Plano Diretor do município do Rio de Janeiro - Lei Complementar n.º 111.** Rio de Janeiro, 2011.

RECH, A. U. **Plano diretor inteligente:** pressuposto **para cidades inteligentes**. Caxias do Sul, RS: Educs, 2019. 129p.

PREFEITURA MUNICIPAL DE RIO LARGO. **Lei Nº 1.208**. Código de Obras e Edificações de Rio Largo. 1997.

RIO LARGO. Plano Diretor do Município de Rio Largo - **Lei Municipal nº 1.549**. 11 de dezembro de 2009. Disponível em: https://sapl.riolargo.al.leg.br/norma/pesquisar?page=4&tipo=&numero=&ano=&data

_0=&data_1=&data_publicacao_0=&data_publicacao_1=&ementa=&assuntos=&salvar=Pesquisar&iframe=-1.

ROMARO, M. C. **Os Aeroportos de Guarulhos e de Viracopos: Análise Crítica de Planejamento e Projeto**. São Paulo. 2007.

SANTOS, M. **A urbanização brasileira**. 5ª ed. São Paulo: Editora da Universidade de São Paulo. 2005.

SÃO PAULO. **Lei nº 16.402**. Plano Diretor Estratégico do Município de São Paulo. 2016. Disponível em: https://www.prefeitura.sp.gov.br/cidade/secretarias/urbanismo/legislacao/plano_diretor/index.php?p=201105. Acesso em: 18 maio 2023.