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NOISE CONTROL FOR A BETTER ENVIRONMENT

MUNICIPAL STRATEGY ON TRAFFIC NOISE REDUCTION – CASE STUDY LISBON

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ABSTRACT

Due to the demands established by the community directives, related to the Assessment and Management of Environmental Noise, and national law, the competency to elaborate strategic noise mapping, the harmonization of indicators and the evaluation methods of environmental noise is responsibility from the Municipality. We aim to support the elaboration of the Action Plans based upon the noise map with the view to preventing and reducing environmental noise particularly where exposure levels can induce harmful effects on human health and to preserving environmental noise quality where it is good. This project will allow the evaluation of environmental noise using common methods, selecting potential critical areas of noise exposure and the following Noise Reduction Plans.
We start with several case studies each leading to a different solution, in order to adopt an environmental strategy of noise reduction.
Careful planning shows that, exposure to noise can be avoided or reduced. Control options should take into account the technical, financial, social, health and environmental factors of concern. Cost/benefit relationships, as well as the cost-effectiveness of the control measures, must be considered in the context of the social and financial situation of each community.

Keywords: noise, ec directive, noise reduction plans, traffic noise, solutions, barriers
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1. Lisbon Geographic Data

With a territory of 85.87km2 and a residential population of 547,733 (2011 census), Lisbon is the centre of a 2.8 million inhabitant metropolitan area with high commuting fluxes, half of whom get to the city by car (2/3 of private vehicles in the city come from surrounding areas). Lisbon city has 213.000 automobiles (388 cars per 1,000 inhabitants), but every weekday 370.000 other cars enter the city.

In an urban area such as Lisbon, the high concentration of social and economic activities, coupled with the increasing availability and accessibility of transport, have transformed urban areas into spaces where preservation of the environment is particularly fragile. Thus, noise becomes ubiquitous, whether from the transport network, collective or personal equipment, which is part of professional activities, leisure or daily life.

In recent years, the increase in tourism has become an additional pressure in terms of noise production, especially in the historic center and in the nightlife areas.

2. Noise Abatement in Lisbon

In the first noise map (in 2000), almost 50% of the municipal area was exposed to values of L_{Aeq} of 65dB(A) or more. Over the last 5 to 10 years this value has been substantially reduced. The noise map currently indicates that only 18% of the area is above a L_{den} value of 65dB(A). Even though these aren't directly comparable indicators (L_{Aeq} and L_{den}), there is a notable decrease in noise in the city.

Sources represented on the map were: road traffic, air traffic, rail traffic and other sources (such as nightlife areas).

The responsibility for developiing the noise map for aircraft and railway noise arises exclusively from operating entities, which Lisbon Municipality has undertaken to involve in its Strategic Noise Map.

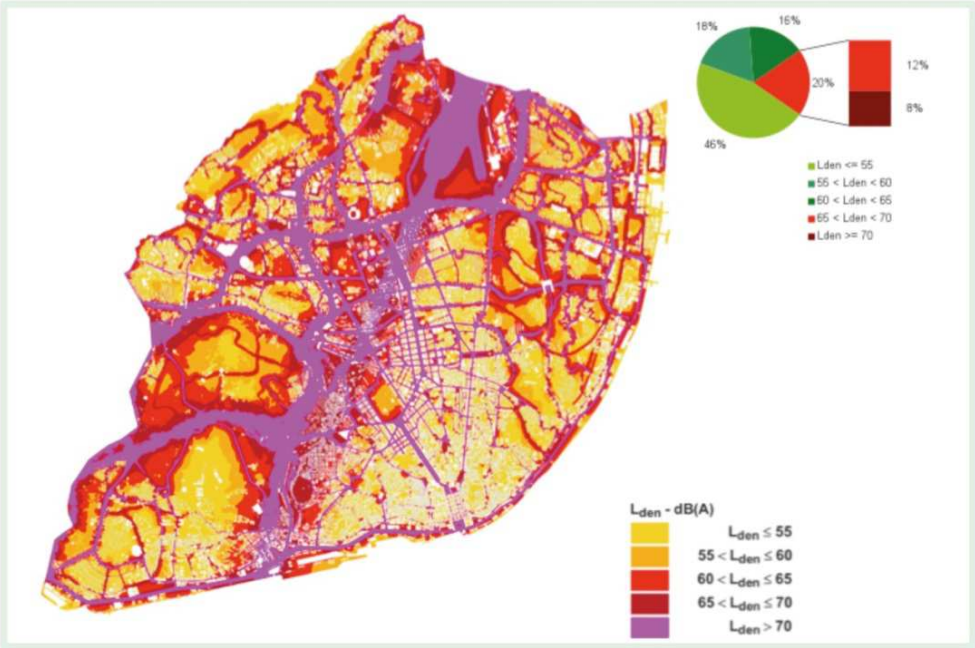

Figure 1 – *Map of Global Noise for day-evening-night and distributions area of noise levels, L_{den} dB(A)*

The distribution of sound levels by area shows that for L_{den}, 20% of the municipal area is above the threshold value. As we can see only 5 % of the area is 10 or more dB(A) above the threshold (65dB(A)).

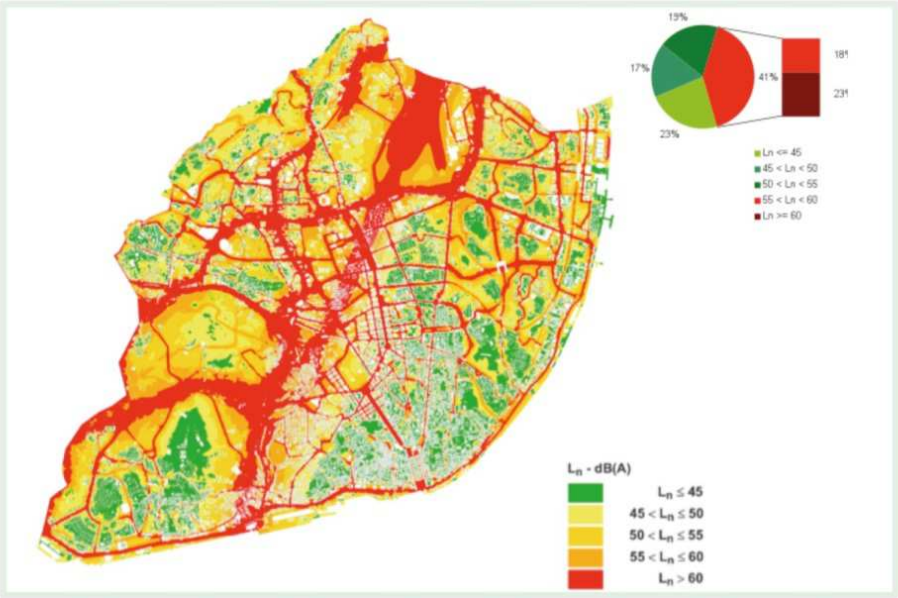

Figure 2 – *Map of Global Noise for night and distributions area of noise levels, L_n dB(A)*

Considering L_n indicator, the area above threshold (55dB(A)) is larger- approximately 41% - of which 23% is 10dB(A) or more.

With this kind of mapping we can determine the number of people affected by different levels of noise, the source of that noise (i.e. road, rail, airports) and the location of the people affected.

Correlating the noise map with resident population reveals that 18% of the population is exposed to levels higher than the regulation for L_{den} indicator ($L_{den} > 65$), where 14% is from traffic noise. Considering values of $L_{den} > 55$, the exposed population increases to about 55%, in which case 45% of traffic noise (table1).

Table 1 – *Population exposed to L_{den} (4m above ground level and "most exposed facade" by noise source)*

L_{den} dB(A)	Global Noise	Road Noise	Train Noise	Aircraft Noise	Other sources
$L_{den} \leq 55$	243.974	300.641	538.658	480.468	544.393
$55 < L_{den} \leq 60$	98.342	85.383	4.398	233.69	242
$60 < L_{den} \leq 65$	103.355	80.540	979	317.22	143
$65 < L_{den} \leq 70$	72.270	57.756	792	7.740	42
$70 < L_{den} \leq 75$	24.710	18.465	0	1.525	4
$L_{den} > 75$	2.175	2.042	0	2	2

Table 2 shows that 22% of the population is exposed to levels above legal limits (L_n> 55) where 17% are composed of traffic. At valuesof L_n> 45, the exposed population increases to approximately 60%, where 50% are connected to traffic.

Table 2 - *Population exposed to L_n (4m above ground level and "most exposed facade" by noise source*)

L_n dB(A)	Global Noise	Road Noise	Train Noise	Aircraft Noise	Other sources
$L_n \leq 45$	218.961	274.314	536.660	474.459	544004
$45 < L_n \leq 50$	102.913	92.694	4.912	23.486	388
$50 < L_n \leq 55$	101.488	83.297	1.987	31.740	246
$55 < L_n \leq 60$	82.676	64.163	819	12.867	140
$60 < L_n \leq 65$	32.738	25.375	448	2.230	41
$65 < L_n \leq 70$	5.789	4785	-	44	4
$L_n > 70$	261	198	-	-	2

Road traffic is thus the major cause of city noise pollution. Reducing/controlling car traffic on the main streets, it is the most difficult challenge, for which focused strategies are gradually being extended over the entire city

3. Improved Sound areas

The Environmental Noise Directive (END) (2002/49/EC) defines quiet areas, both inside and outside agglomerations, as follows: *"A quiet area in an agglomeration shall mean an area, delimited by the competent authority, for instance which is not exposed to a value of Lden or of another appropriate noise indicator greater than a certain value set by the Member State, from any noise source. A quiet area in open country shall mean an area, delimited by the competent authority, that is undisturbed by noise from traffic, industry* or recreational activities."

The historic neighborhoods with conditioned access, the neighborhoods and priority intervention areas (BIP / ZIP) and the green spaces were assessed as quiet zones to assess compliance with the requirements described in the END.

This methodology allowed to identify 12 quiet zones

Despite the formal quiet areas, the municipality has been working to increase the area exposed to low noise levels with a holistic approach taking advantage of green areas as low noise level zones in the belief that this will be a guarantee of a new urban development for the inhabitants of urban centres.

At present, about 25% of Lisbon (much of them green zones) has noise values compatible with the quiet zones. This represents 89% of Lisbon inhabitants who live within 300m of a "low noise level zone" which can be equated to a quiet zone.

4. Lisbon's Action Plan

The Action Plan (AP) is broader and more ambitious than a simple noise reduction plan. The challenge is to seek further noise reductions at source, while using development layout, building design, traffic management and other means to minimise noise exposure, and achieve progressively better soundscapes.

It aims to define measures to reduce environmental noise and eliminate legal irregularities, define preventive measures to preserve acoustic environment quality, in particular through the maintenance and extension of "quiet" areas.

The AP focuses particularly on major environmental noise sources, namely road, rail, and air traffic, and other sources of relevant permanent noise activities (bars, pubs, entertainment and other comercial premises).

Night is the most critical period for noise exposure and the criteria to determine intervention priority areas were based on Ln. Priority areas are those where the population is most exposed to higher values (L_n > 60dB(A)).

With this methodology, a map was obtained where it was possible to identify which roads had a larger number of inhabitants exposed to values of L_n above the stipulated.

The identification of the zones was made based on main axes that in itself constitute a source of noise for the surrounding, or, by the aggregation of several interconnected routes, whose intervention could be a strategy at the level of the block or of a neighborhood.

In the case of major roads (mostof them local highway), namely the IP7 - North-South axis, Segunda Circular, IC17 - CRIL, A5 and the Radial de Benfica, whose area of influence in terms of sound levels often extends beyond the buildings, the zone of intervention was delimited based on the area of conflict associated with each of these axes.

The AP was developed with interdisciplinary collaboration between Municipal departments and/or external partnerships, including NGOs and resident associations.

The draft AP was available for consultation on the internet. The Public Weighting Discussion Report included all shared information (suggestions, comments, and complaints) received in public consultation.

As the main source of noise in Lisbon is road traffic, each route is evaluated in terms of the number of people exposed to different classes of environmental noise.

A total of 29 zones were defined, measures for noise reduction applied and effectiveness of the proposed measures quantified.

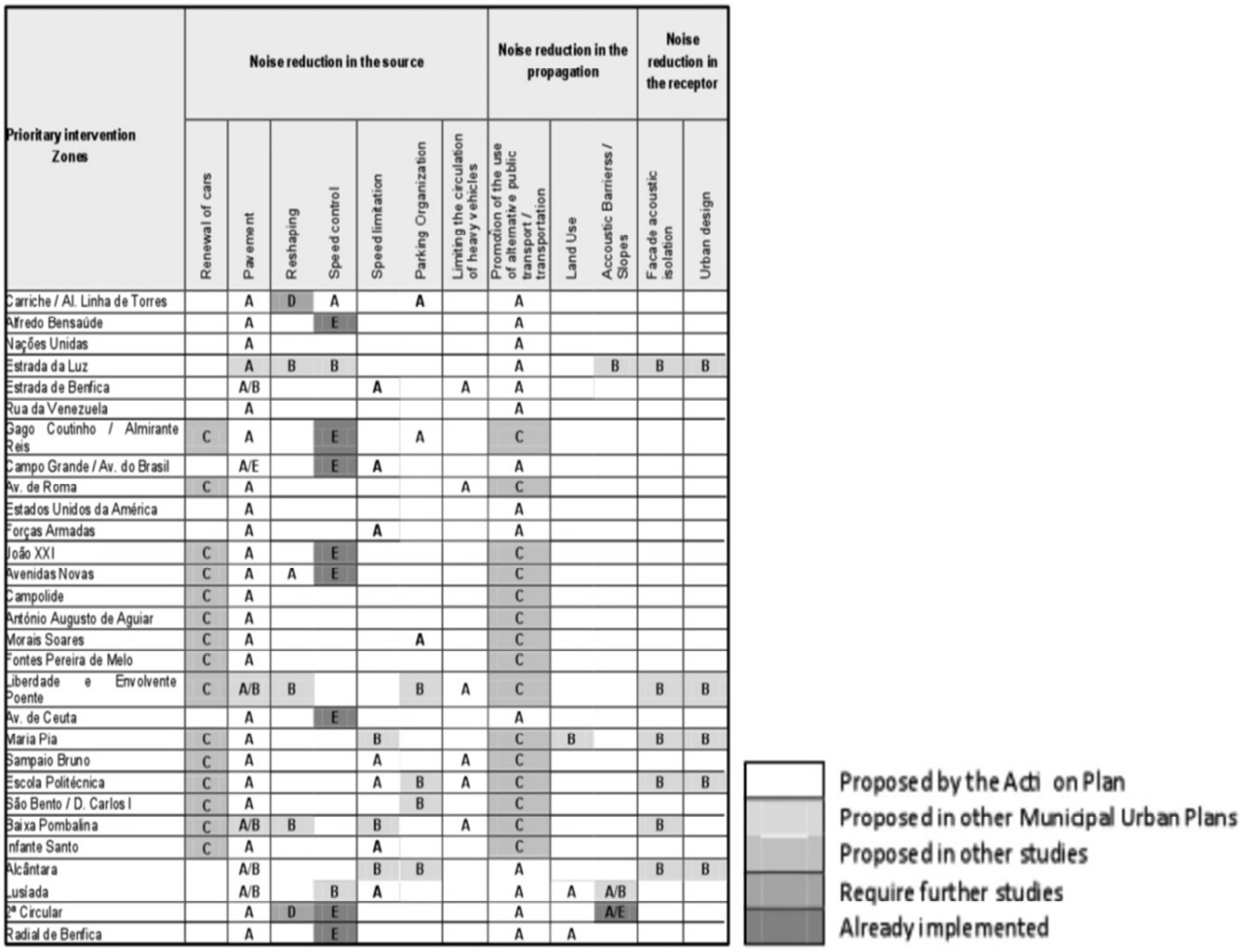

Figure 3 *– Action Plan Matrix, A Lisbon Noise Action Plan*

4.1. Emblematic areas

Avenidas Novas

The resurfacing with porous pavement was proposed in the main arteries: Av. 5 de Outubro; Av. Da República; Av. Defensores de Chaves; Rua Dr. Eduardo Neves; Av. António Serpa; Av. Júlio Dinis; Av. De Berna; Av. Barbosa Du Bocage; Av. Elias Garcia; Av. Visconde de Valmor; Av. Miguel Bombarda; Av. João Crisóstomo; Av. Duque de Ávila; Rua das Picoas and Av. Praia da Vitória.

Av. Duque d'Avila, was reshaped and the AP proposed a similar intervention in Av. Elias Garcia. This reshape comprises the suppression of one of the directions of the way, with the partial pedonalization of the avenue and installation of a bicycle lane.

This zone is already inside the Low Emission Zone of Lisbon.

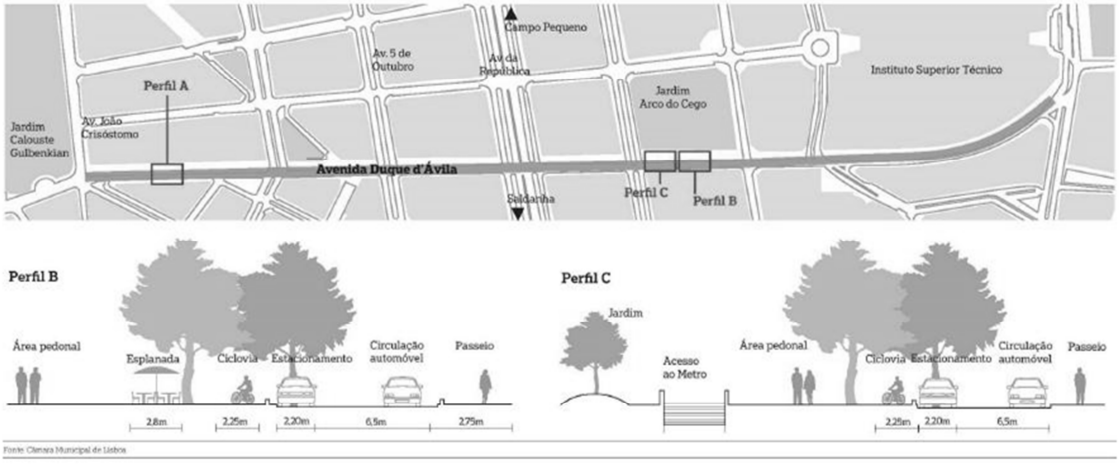

Figure 4 *– Av. Duque D´Avila reshaping project*

Baixa Pombalina

Most of the area is covered by a Small Scale Plan. The intervention area was subjected to noise reduction measures, which resulted in the adoption of porous pavement and the reduction of velocity to 30 km / h in: D. Pedro IV Square; Rua da Conceição; Rua de S. Julião; Street of trade; Rua da Alfândega; Arsenal Street; Rua Áurea (from Ouro); Rua da Prata; Rua dos Douradores; Rua dos Fanqueiros and Rua da Madalena. All study area was subject to a traffic conditioning plan (dedicated bus lane and restriction to crossing traffic)

This zone is completly inside the 1st phase of Lisbon's Low Emission Zone.

Table 3 – *Noise expected reduction for Baixa Pombalina*

	Before the plan (measured)		**After the plan (simulated)**	
	L_{den} dB(A)	**L_n dB(A)**	**L_{den} dB(A)**	**L_n dB(A)**
Rua da Prata	76.9	70.1	71	61
Rua do Ouro	75.7	70.0	72	62
Rossio	75.0	67.3	69	57
Praça do Comércio	71.9	63.6	61	51
Rua da Conceição	71.1	62.9	68	60
Rua dos Fanqueiros	71.3	64.7	66	64
Praça da Figueira	72.9	65.9	71	62
Rua da Madalena	71.3	64.4	66	55

4.2. Impact reduction Forecast

The following tables show existing soundscapes improved with the measures relating to L_{den} and $L_{n.}$

Table 4 - *Forecast reduction in the share of population (rounded to hundreds) exposed to different classes of values of L_{den} in dB(A) for road traffic noise.*

L_{den} dB(A)	**Before AP**	**After AP**	**Reduction (%)**
$L_{den} \leq 55$	300.600	328.400	-
$55 < L_{den} \leq 60$	85.400	80.300	6.0
$60 < L_{den} \leq 65$	80.600	76.800	4.6
$65 < L_{den} \leq 70$	57.800	48.500	16.1
$70 < L_{den} \leq 75$	18.500	10.300	44.3
$L_{den} > 75$	2.000	700	65.0

Table 5 - *Forecast reduction in the share of population (rounded to hundreds) exposed to different classes of values of L_n in dB(A) for road traffic noise.*

L_n dB(A)	**Before AP**	**After AP**	**Reduction (%)**
$L_n \leq 45$	274.300	311.300	-
$45 < L_n \leq 50$	92.700	83.100	10.4
$50 < L_n \leq 55$	83.300	80.200	3.7
$55 < L_n \leq 60$	64.200	54.000	15.9
$60 < L_n \leq 65$	25.400	15.200	40.2
$65 < L_n \leq 70$	4.800	1.100	77.1
$L_n > 70$	200	0	100.0

- After AP implementation, the class over 70dB(A) is not in use for the L_n indicator.
- Between 65 and 70dB(A) a reduction of 77.1% is observed.

Since the primary objective of the AP is in L_n exposed to levels exceeding 60dB(A) population, the measures have led to an improvement for 46% of the exposed population.

There was a 52% reduction of the population exposed to higher values of Lden over 70dB(A) and 51% of people exposed to Ln values over 60dB(A) for the priority intervention areas.

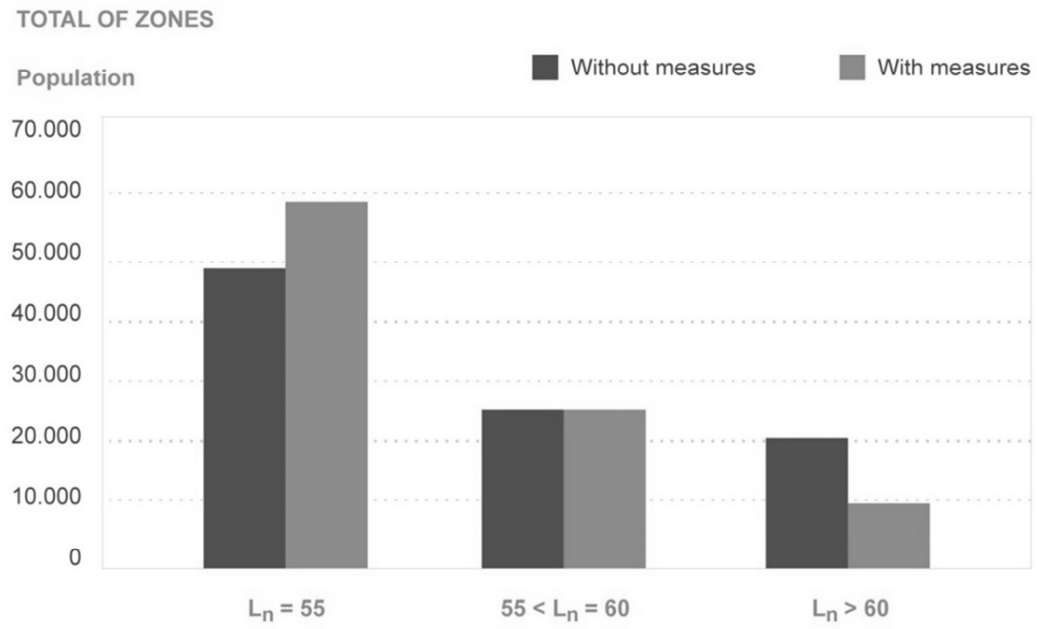

Figure 5 – *Distribution of the number of inhabitants in the total study areas, exposed to different classes of indicator values L_n in dB(A)*

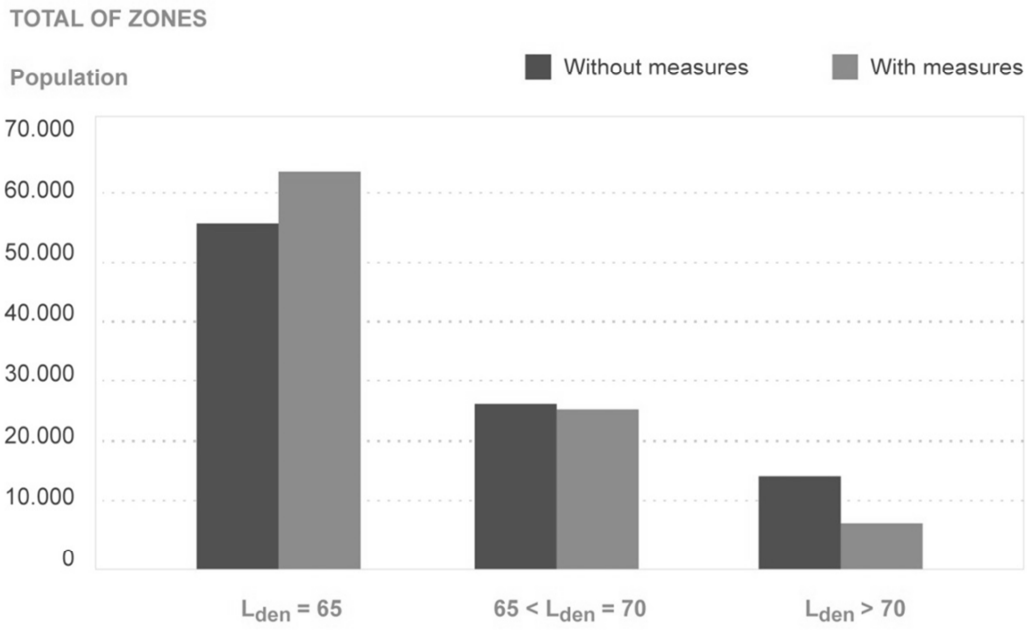

Figure 6 – *Distribution of the number of inhabitants in the total study areas, exposed to different classes of indicator values L_{den} in dB(A)*

5. Cost – Benefit analysis

Achieving major improvements in the complex sound environments of major cities can be very costly.

The cost benefit analysis gives a relevant contribution to the decision support.

The cost of noise reduction measures of the AP were compared with the possible monetary benefits resulting from the implementation of these measures.

The reduction of these costs and losses were considered to be the benefits of carrying out the noise reduction measures. Finally, this comparison between costs and benefits was evaluated through an economic-financial analysis for each of the 29 AP intervention areas.

Considering the large cost of AP total shares, around 9M €, three phases of implementation of the plan have been established, corresponding to modules of 5 years each, with an estimated investment of around 3M €.

It should be noted that in the first phase 24 areas would be involved, corresponding to a reduction in the population exposed to noise levels above the legal limit of around 79% and to an investment of approximately one third of the total.

The second phase comprises only one zone- "2nd circular" -, which corresponds to a reduction of the population exposed to noise levels above the legal limit of 13% and approximately one third of the total investment.

The third stage provides for intervention in four areas, which are cost-benefit analyzes of less than 1, which are therefore disadvantageous in the financial framework, and therefore have as a whole a reduction of only 8% of the exposed population and a third of the total investment allocated to AP.

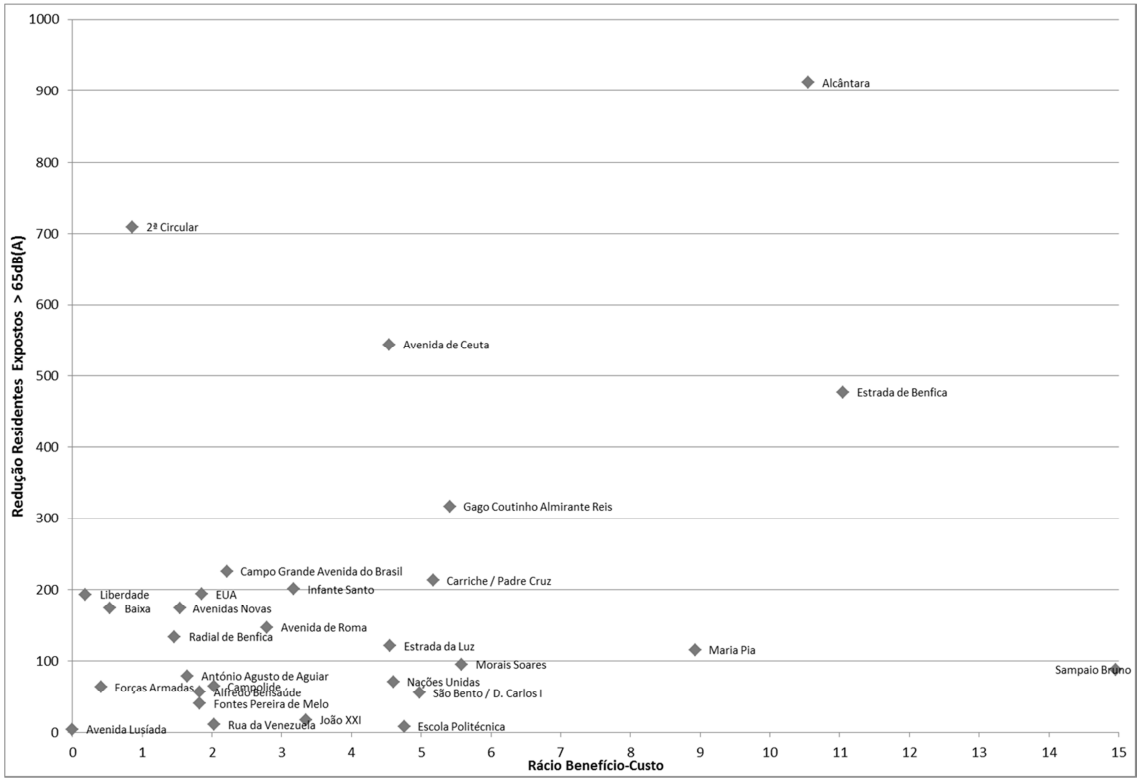

Figure 7 – *Zones depending on the reduction of exposed residents > 65 dB (A) and Cost-Benefit ratio*

6. Future

Current local politics reflect the will of Lisbon users, creating a “Lisbon for people” and no longer for cars, with a set of specific actions that empower walking, cycling and public transport, along with new and innovative mobility services, focosing on sharing and aiming at the reduction of traffic volumes and their negative environmental impacts.

Amongst the measures that have been implemented over the last years to promote sustainable mobility in Lisbon, the following deserve notice:

• Conversion of several streets into pedestrian areas, promoting and defending walking and local commerce;

• Creation of pedestrian routes linking historical neighborhoods, including mechanical apparatus (several vertical lifts and funiculars) in hilly historical areas where car circulation is difficult and cars were mainly parked on sidewalks;

• Development of the Pedestrian Access Plan defining guidelines and actions to promote walking and citizen inclusion;

• Implementation of school mobility programs, such as safety projects, Pedibus and Bike to School;

• Creation of a cycle infrastructure network, with 90km of dedicated bicycle paths and protected lanes linking important urban areas of the city, including 6 pedestrian-cycle bridges to overcome important physical barriers (freeways, arterial roads, railways, and deep valleys) and metal ramps on stairs;

• Creation of Low Emission Zones (approximately 30% of Lisbon territory) centered in the downtown areas, where private vehicles can only enter if they comply with a certain Euro standard

• Creation of 7 30km/h zones and shared zones, with traffic calming measures that reduce traffic crossing in residential and commercial neighborhoods, increasing road safety and assuring easier walking and cycling (32 zones planned, 6 zones operational - 48km streets adapted);

In the first semester of 2019, the Strategic Noise Map will be reassessed, with around 200 traffic counts, which will allow us to adjust the Noise Action Plan to the new dynamics of the city.

A comparative assessment will be carried out using the methods used in the 2011 map and the new version of the map will incorporate Common NOise aSSessment methOdS (CNOSSOS-EU) for road, railway, and aircraft noise.

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