

Tranquilization of urban areas in small and medium sized Mediterranean cities: implementation of regulations and solutions in the cities of Heraklion, Rethymnon and Florence (period from 1993 up today)

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Summary

Inhabitants of urban areas often suffer from high environmental noise levels in combination to the lack of other factors which could reduce the annoyance and increase tranquility. Consequently, noise action plans have to face and balance needs for quality of life improvement and avoidance of disturbances in everyday life. Nowadays plenty of data from researches, action plans and applications aimed to improve the urban acoustic environment are available. In this paper the considered urban areas are Heraklion and Rethymnon (respectively a medium and a small sized city in Crete Island) and Florence (a medium sized city located in the center of Italy). Moreover, contributions of two EU LIFE projects (HUSH and QUADMAP) mainly regarding critical and quiet areas and the proposed interventions for the rehabilitation and the improvement of the urban acoustic climate by actively involving the population are reported. The existing data prove that the above measures and plans have significantly contributed to the reduction of noise levels and to the improvement of tranquility.

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1. Introduction

Environmental noise is an important risk stressor in urban areas and it is strongly related to health and wellbeing burden [1-2]. Prevention of burden of the noise environment and tranquilization of affected areas should be within the priorities for sustainable urban planning [3]. Often, the required reduction of noise emissions and noise propagation is not feasible, because of the complex canopy and operations of urban areas. Beyond the direct noise level reduction, other parameters have been identified, which contribute to the reduction of the perception of the annoyance and the associated negative impacts (i.e. landscape, green, etc.). Within this paper, relative cases of 3 Mediterranean cities are presented. Data from implemented urban plans and their influence to the quality of noise environment and tranquilization are presented in relation to noise levels, direct response of people (questionnaires) and raise of activities which prove the relative raise of attractiveness of the examined areas.

2. Cities key studies

2.1. Heraklion city

It is the major city of Crete with 200.000 residents, where the 2nd busiest airport of Greece, major port (commercial, cruise, passengers), significant part activities of Crete (administration commerce, manufacture, hospitals, universities) are located. Cnossos was the first important agglomeration (about 2000 B.C.) and since then the urbanization of the area has been increasing. From the period of early '70 the growth of the city was rapid and therefore it was an increasing demand of infrastructures (housing, road network, etc.). The town planning and the infrastructures development failed to respond to the needs in a timely and effective manner. It was created an "anarchy" urban canopy unable to absorb the new needs (significant lack of public spaces, saturated road network, noisy and annoying environment, etc.). Since 2000, a program of major interventions and rehabilitations is on progress. Therefore, there are significant improvements to noise environment and quality of life. The above evolution is presented below (A: town level, B: local level).

A) HERAKLION TOWN LEVEL
1st Noise Map (1993) based on measurements

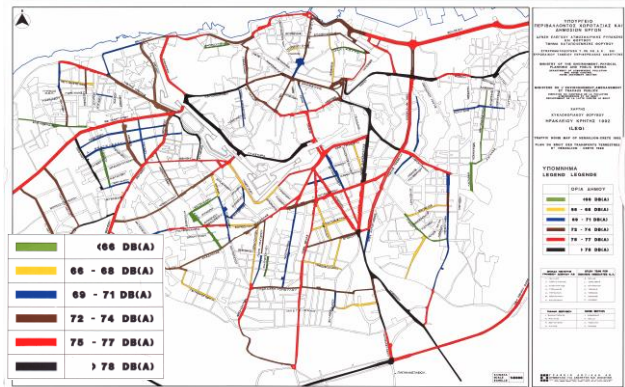


Figure 1. Leq Noise Map (1993).

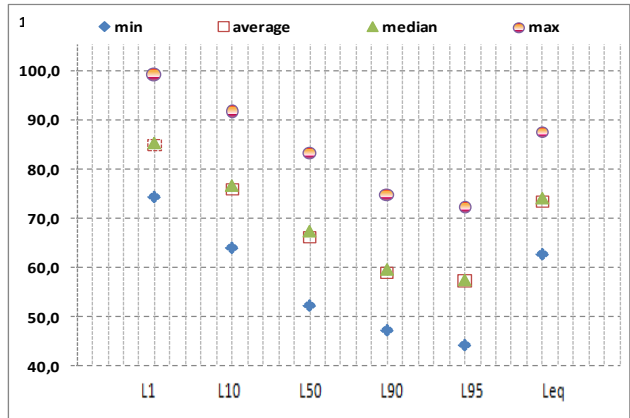


Figure 2. Noise indexes fluctuation - measurement 1993.

Table I. Fluctuation of noise indexes (1993).

	L1	L95	L50	L90	L10	Leq
average	84,9	57,3	66,1	58,9	75,9	73,4
median	85,3	57,5	67,4	59,7	76,7	74,1
max	99,3	72,5	83,5	75,0	91,8	87,6
min	74,3	44,3	52,3	47,3	64,0	62,7

Table II. Distribution (%) of citizens opinion about their perception for the quality of noise environment per zone².

Quality	Noise zones (dB(A))					
	>77	75-77	72-74	69-71	66-68	≤66
Quite	3	13	5	10	28	32
Noisy	23	29	10	30	48	60
Very noisy	73	58	85	60	24	8
Other	1	0	0	0	0	0
Total	100	100	100	100	100	100

Conclusions about situation on 1993: most of the residents along main and secondary road network had the perseption of a noisy/very noisy acoustic environment.

² Social research in Athens Greece (YPEKA 1997)- similar conditions to Heraklion

2nd Noise Map (2013) (implementation of 2002/EK)³

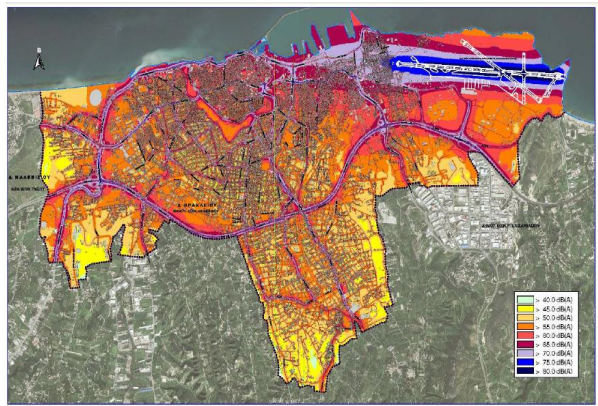


Figure 3. L_{den} Noise Map (2013).³

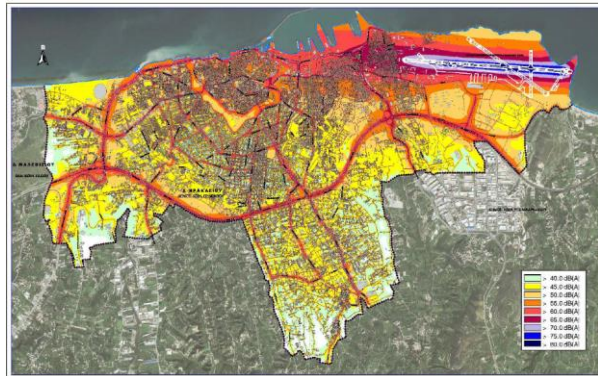


Figure 4. L_{night} Noise Map (2013).³

Table III. Population exposure per noise zone (2013).³

Noise zone	Population per noise zone			
	Lden	Lnight	Lden	Lnight
<45	37.987	73.474	26,2%	50,8%
45 -50	27.700	23.392	19,1%	16,2%
50- 55	24.024	24.641	16,6%	17,0%
55 -60	24.950	14.130	17,2%	9,8%
60- 65	18.432	5.739	12,7%	4,0%
65-70	6.170	3.398	4,3%	2,3%
70-75	5.177	0	3,6%	0,0%
>75	334	0	0,2%	0,00%
total	144.774	144.774	100%	100%

Table IV. Fluctuation of noise indexes (measurements 2013) and change compared to measurements 1993.

	Year 2013				1993-2013	
	Lnight	Lden	L10	Leq	ΔL ₁₀ (‘93-’13)	ΔL _{eq} (‘93-’13)
average	64,2	72,3	73,0	70,5	2,9	2,9
median	64,9	72,5	73,4	70,9	3,3	3,2
max	68,5	76,6	78,7	76,0	13,1	11,6
min	52,2	58,1	61,2	57,3	2,8	5,4

³ Strategic Noise Map and Action Plan of Agglomeration of Heraklion 2013 (ADK S.A.& N. KOLETIS)

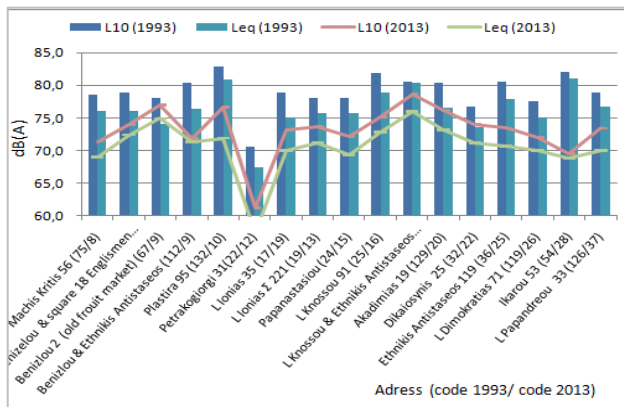


Figure 5. Comparison of fluctuation of noise indexes Leq, and L10 along main and secondary road network (measurement 1993 and 2013).

Conclusions about the evolution of environmental noise from traffic - situation on 1993 and on 2013:

- (1993): most of the residents along main and secondary road network had the perception of a noisy/very noisy acoustic environment.
- (2013): most of the residents along main and secondary road network are exposed to noise levels above the national limits ($L_{den} \geq 70$, $L_{night} \geq 60$ dB(A)).
- (Comparison 2013 to 1993): despite the fact that today the volume of fleet of vehicles has doubled comparing 2013 to 1993 (increase of vehicle ownership index), the noise level along main and secondary road network of Heraklion has been significantly reduced.

Interventions that have improved the acoustic environment at city level are the following:

- Main road network integration: external peripheral road (BOAK), internal peripheral road (Petaloeidis), coastal road, vertical axes which connect directly the external peripheral road with main destinations (port, airport, etc.). Relative effects: (i) diversion of through traffic from urban areas, (ii) reduce of trucks and intercity buses traffic (most of them use vertical axes and peripheral roads)
- Normalization of urban traffic conditions: improved traffic management, one way roads, pedestrianization of roads smoothing of traffic characteristics (urban round-about at intersections, reduce of speed, reduce of acceleration and deceleration, etc.).

(B) HERAKLION HISTORICAL CITY CENTER & COASTAL ZONE-LOCAL LEVEL

During last decade, city center and coastal zone have been improved significantly in terms of landscape, availability of public areas and facilities, mobility, etc. (extended pedestrianization of roads at historical city center, restoration of heritage buildings, development of an extended coastal front zone with significant interventions, development of promenade, areas for open-air activities and sports, etc.).

Pedestrianization of historical city center

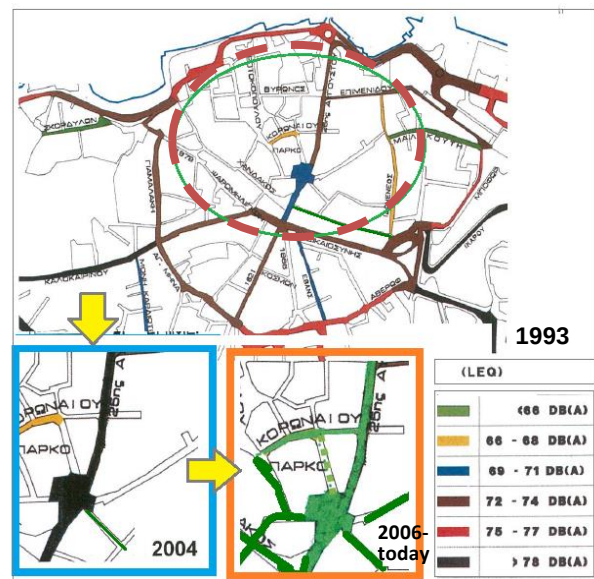
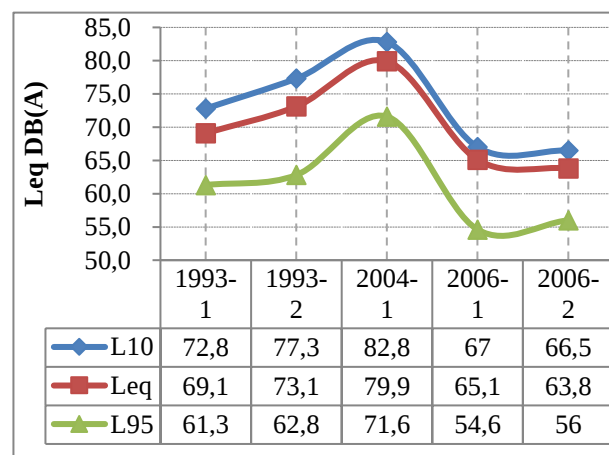


Figure 6. Noise maps at pedestrianized area of city center based on measurement (1993, 2004 before and 2013 after pedestrianization).

Table V. Noise measurements at pedestrianized area at city center (1993, 2004 before, 2013 after interventions).



The increase of noise level was significant during decade 1993-2004 -about 10dB(A)-. After pedestrianization of road network, noise level reduced about 15dB(A) compared with 2004 levels and about 6dB(A) compared with 1993 levels.

Furthermore, there have been extensive works for the restoration of buildings, improvement of public spaces, lighting, etc. In the short time the area became the heart of the city, with intensive use of open spaces, many events throughout the year, several new recreation and commerce businesses.



Figure 7. Pedestrianized area at city center prior and after interventions.

People of all ages seems to accept the new situation enthusiastically (visitors and professionals). They recognize the improvement regarding tranquility, landscape, safety, comfort of use the public space, offer of recreation and commerce activities.

Heraklion coastal area development - local level

Extended coastal zone has been developed in the last 15 years. Prior, the area was absolutely undeveloped and the city seemed to “have turn its back” to the sea. A new road was constructed along the sea front, where significant interventions were necessary. Additionally, a long promenade, areas for open-air activities and sports, etc. have been constructed next to the sea. Quality of noise environment at the area is presented below.



Figure 8. Noise Map (Lden) -2013 at the coastal area. ³

Noise level along the coastal road are high (>70 dB(A)). A lot of people of all ages seems to visit the area and have activities (sports, walking, enjoy the sea, rest, use the outdoor facilities, etc.) and seems that they are not disturbed from noise level. It is a priority for them to spend time at the only promenade next to the sea, relatively close to their home, in an area with a nice landscape, safe and comfortable outdoor facilities.



Figure 9. Coastal area situation prior and after interventions.

2.2. Rethymnon city

The first evidence for habitation in Rethymno are dated back to the Late Minoan period (1350-1250 BC). Today the city is built in the same place as ancient Rithymna which reached its peak in the 4th and 3rd centuries BC. Since then, city development passed through periods of decline. Today is a small city, developed along the beach. In center there is a well preserved old town, where the majority of commerce and recreation activities are located. A period of intense growth began in the '80s mostly because of tourism sector and university activities. Soon, public infrastructures had become inadequate (saturated and noisy road network, inadequate pavements, presence of contrasting land uses and degraded landscape at the old town, etc.).

Since then, municipality authorities have set an ambitious program for rehabilitation of the city, with special care for the old town, seafront area, traffic management, etc. Major interventions have been

implemented and further plans are foreseen, to achieve sustainable development of the city, focusing to the quality of life, the protection of environment and the economic growth.

Main interventions at the old town are: rehabilitation of buildings, rehabilitation and extension of infrastructure and public areas, huge interventions of roads pedestrianization, traffic restrictions, control of land uses location and operation.

Interventions at seafront area: construction of promenade about 5km long, with facilities adequate for pedestrians, bicycles, outdoor activities, etc.

Interventions along main road network: traffic management, new vertical axes (connections to external peripheral road – BOAK), pavements extension to increase the number of pedestrians and a separated lane for bicycles.

Data for the quality of noise environment, the behavior and perception of annoyance of residents and visitors, the longterm transformation of the city, etc, are available from social research (1998), noise map based on measurements and action plan (2004), recent field survey and experience.

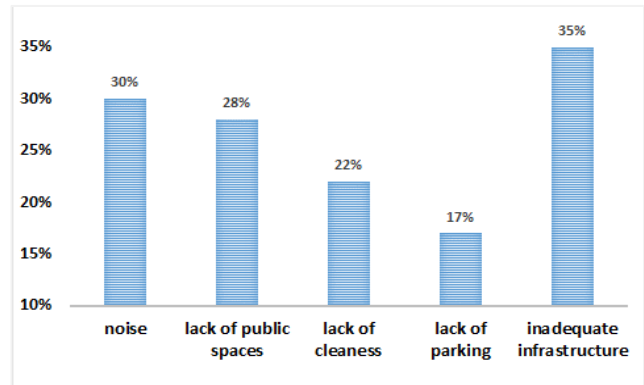
Social research (1998, NTUA and Old Town Office “Functional pattern and Protection of Old Town”).

The social research was based on questionnaires distributed to residents at the “old town” and public bodies. Outline of the relative conclusions are presented below.

- a.) 97% of respondents stated that pollution was the major problem of the old town (noise, lack of cleanliness, need for restoration of buildings and public space, etc.).
- b.) As another major burden factor was referred the lack of green & public spaces, necessity for restoration of existing public areas, and of urban landscape etc.
- c.) Residents stated that they wanted the removal of disturbing land uses (manufacture, wholesale, noisy recreation activities, etc.).
- d.) Highest annoyance from noise was referred to night period.
- e.) Residents referred that the most important factor of annoyance was: 30% environmental noise, 28% lack of public spaces.
- f.) Residents and people activated professionally at the area stated about significant factors of annoyance: 32% noise, 35% inadequate infrastructure of water supply and sewage pipe network, 22% lack of cleanliness, 17% lack of parking, traffic problems (30%, of professionals) etc.

- g.) 15% of residents referred their intention to move out of the old town, because of environmental and infrastructure problems. 43% of them referred that the noise pollution was an important parameter to their decision.

Figure 10. People opinion for most disturbing annoyance factors.



Noise map and action plan (2004)

Noise map was based on noise measurements. Leq levels variation in relation to road classification is presented to the table below.

Table VI. Leq levels variation.

Leq	primary arterials	secondary arterials	collector roads	local roads
average	76,0	72,1	67,6	66,6
median	76,8	72,3	67,5	67,5

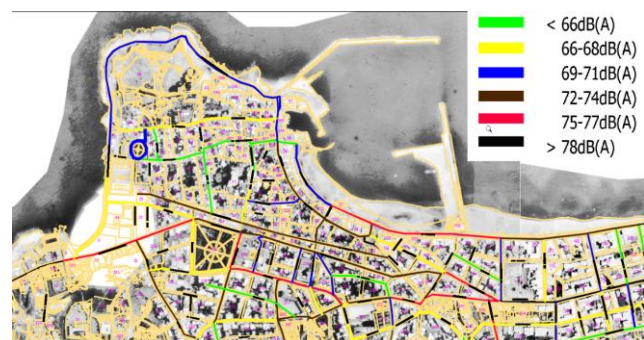


Figure 11. Noise map Led (2004) & points of measurements.

Table VII. Population exposure.

noise zone	Population exposure	% population
Leq $\geq$ 78 dbA	1469	5.27
75 $\leq$ Leq $\leq$ 78 dbA)	1246	6.73
72 $\leq$ Leq $\leq$ 75 dBA	1278	8.8
69 $\leq$ Leq $\leq$ 72 dBA	1116	4.47
66 $\leq$ Leq $\leq$ 69dBA	2468	4.00
Leq $\leq$ 66 dBA	19691	70.65
total	27868	100

Current situation

Most interventions mentioned above have been implemented. Thus, the profile of the city has been changed significantly. More people choose to move on foot or by bicycle because of comfortable and safe pavements along main road network and pedestrianized roads. They characterize the improved situation as not disturb and not “confused” them as before. They enjoy the improved landscape too. The effect of noise has less importance than before.

The old town area is the “heart of the city” again, where most of commercial, administration and recreation activities are located. It is the main destination for tourists visiting the city. Residents and visitors are enthusiastic from urban landscape, the restored buildings and public areas, the aspens of traffic, the tranquility, etc. Additionally, they use intensively the seafront promenade even though noise levels are relatively high.

Visitors often characterize Rethymnon as a nice city to visit and to live, because of the scale, the landscape, tranquility, the comfortable and safe conditions to move on foot and by bicycle, etc.



Old town Aerial view



Sea side promenade



Old town center

Pedestrian & bicycles infrastructure along main road network

Figure 12. Interventions carried out in Rethymnon.

2.3. Florence city

At the Italian level, the Tuscany Region has always been one of the most avant-garde regions concerning the noise management and the application of the most recent legislative instruments, with particular reference to the European Directive 2002/49/EC (END) [4].

More specifically, the city of Florence has been one of the first cities to comply with the requirements of Italian national legislation about noise, providing in early 2000 the acoustic zoning and the Noise Reduction Plan. Moreover, it was one of the first agglomerations to fulfil the objectives of the END, performing the strategic noise mapping and, as first in Italy, the consequent Action Plan, thanks to which it has been possible to tackle organically acoustic criticalities and to preserve quiet areas, by redeveloping the soundscapes as well.

In the last 10 years the City of Florence has put efforts into the reducing environmental noise, acting in different frameworks such as planning, mitigation, control, as well as through the ordinary activities of authorization and inspection of commercial businesses and economic activities.

In this frame, important issues have been the results obtained through the European projects LIFE+2008 HUSH (Harmonization of Urban Strategies for Homogeneous Action Plans) [5-6] and LIFE+2010 QUADMAP (QUIet Areas Definition and Management in Action Plans) [7-8] during which a central role has been attributed to the public participation of citizens in terms of participatory design of implemented interventions.

The HUSH project has been developed in 3 phases:

- 1) Comparison and the analysis of the current existent laws at regional, national and European level, in order to identify and solve normative contradictions and to propose efficient solutions and procedures, able to fulfil the requirements of the different laws concerning the sound recovery, not always coherent between them;
- 2) the definition of a new procedure for data collection and elaboration system in order to realize Action Plans foreseen by the END, that is to plan the necessary actions and strategies to optimize the management of the acoustic climate. The aim is to define a data model adequate for the city of Florence, but also replicable and exportable to other similar contexts;
- 3) results and data elaboration in order to propose European and national legislative updates.

During the HUSH projects some pilot areas have been selected inside the City of Florence where a process of participatory designing with stakeholders has been carried out in order to define noise reduction interventions.

In the first pilot case, Don Minzoni Primary School, identified in Florence Action Plan as a hotspot, the main identified problem was traffic noise (Fig. 13). Carried out interventions consist in a visually non-intrusive integrated noise barrier, enjoyed by the children during playtime, provision of games with educational purposes and an amphitheatre to have lesson in the garden.



Figure 13. Don Minzoni pilot school - Florence - HUSH Project.

The second pilot case, the urban area of Brozzi-Quaracchi, includes the historical quarters of Brozzi and Quaracchi, in the north-west of Florence (Fig. 14). The area is delimited by two major roads. Noise annoyance to the population is mainly caused by the flow of vehicles crossing the area between the two main roads using local streets rather than the road system outside the quarter. Main carried out interventions concern the realization of 30 km/h zones, raised pedestrian crossings, change in direction of traffic on certain roads and the realization of sound sculptures.



Figure 14. Brozzi-Quaracchi pilot area – Florence – HUSH Project.

The main objective of QUADMAP project was to develop a harmonized methodology for selection, assessment (combining quantitative and qualitative parameters) and management (noise mitigation,

increasing of usability of areas and users satisfaction) of Quiet Urban Areas (QUAs).

QUADMAP Project has met the challenge of defining a methodology to select, analyse and manage Quiet Urban Areas (QUAs) which has been tested in 10 Pilot Areas located in Florence (6 school yards), Bilbao (a square and a green corridor) and Rotterdam (2 public parks).

In Florence it has been decided to apply the methodology in 6 schoolyards (De Filippo, Paolo Uccello, Manzoni, Dionisi, Vamba, Fedi) selected according to:

- the Action Plan of the city of Florence which recognizes schoolyards as Quiet Areas
- the P.C.R.A. (Noise Reduction Plan) of the city of Florence which recognizes the six schools as critical
- selection criteria defined by the QUADMAP methodology (noise map/use and function).

Main interventions carried out in Florence are traditional and green noise barriers, road signs containing the prescribed speed limit of 30 km/h, vegetations and cube seats (Fig. 15).



Figure 15. QUADMAP Project: interventions carried out in Florence.

Scores obtained from questionnaires submitted to citizens about the general evaluation of each pilot area in post-operam scenarios are definitely higher than those of the ante-operam ones.

3. Conclusion

Residents' and visitors' perception of quality of environment and life is shaped from parameters of noise level, landscape, safety and comfort of infrastructures, etc. Their tolerance to noise is extended when the other parameters are of good quality. Therefor noise action plans, urban plans, traffic management plans, etc., should have an integrated approach so that they could achieve a tranquil environment and sustainable development, covering the needs and trends of the examined urban area.

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