

Research Article

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LIFE+2010 QUADMAP Project: a new methodology to select, analyze and manage Quiet Urban Areas defined by the European Directive 2002/49/EC

DOI 10.1515/noise-2016-0009

Received Nov 13, 2015; accepted Mar 16, 2016

Abstract: Concerning quiet areas, the definition provided by the Environmental Noise Directive (END) is intended to preserve the acoustic environment in those areas where it is considered good, according to general indicators and limits. However, the END is not clear enough to allow appropriate assessment and management in urban environments.

The aim of QUADMAP project was to deliver a method and guidelines for the identification, delineation, characterization, improvement and management of Quiet Urban Areas (QUAs) as defined by the END. The Project also wanted to help clarify the definition of a QUA, its meaning and its added value for cities in terms of health, safety and lowering stress levels.

In this article, after an introduction of the current European scenario on QUAs, the main aspects of the methodology introduced for the selection, analysis and management of QUAs are described. Eventually, the major results achieved by the Project, in terms of the guideline on QUAs, the implemented interventions and the achieved benefits, are reported and discussed.

Keywords: quiet areas; environmental noise; soundscape; noise mapping; action plan

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1 Introduction

Noise causes annoyance in almost all European cities and it strongly affects the population's perception of quality of life. It is part of European Community policy to achieve a high level of health and environmental protection and one of the pursued objectives is protection against noise. Concerning quiet areas, the European Directive 2002/49/EC [1] (hereinafter abbreviated as END) defines a "quiet area in an agglomeration" as "an area, delimited by the competent authority, for instance which is not exposed to a value of L_{den} or of another appropriate noise indicator greater than a certain value set by the Member State, from any noise source".

In other words, "quiet areas in an agglomeration", addressed in this article as Quiet Urban Areas (QUAs), can be considered as places whose acoustic climate should be preserved because a noise indicator is lower than a threshold established by each Member State, according to the END. The current definition set by the END appears to be extremely generic and it does not provide usable procedures to be applied in each country for the selection, analysis and management of QUAs [2–4]. Moreover, in the countries or cities where some criteria to deal with QUAs have been adopted, different approaches, both qualitative and quantitative, have been used until now to analyze and evaluate these areas [5]. Consequently, current practices about selection, assessment and management of QUAs in EU countries, though regulated by the END, are extremely fragmented and inhomogeneous.

A further issue concerns the fact that areas where the public expects to find a quiet environment (e.g. public parks, gardens, open urban spaces, squares and school courtyards) often exceed noise thresholds defined by national law, where such noise limits or laws exist. Therefore, as well as the need to recognize and protect areas that actually are quiet, there is also the problem of how to identify and manage areas that have a social role but are not actu-

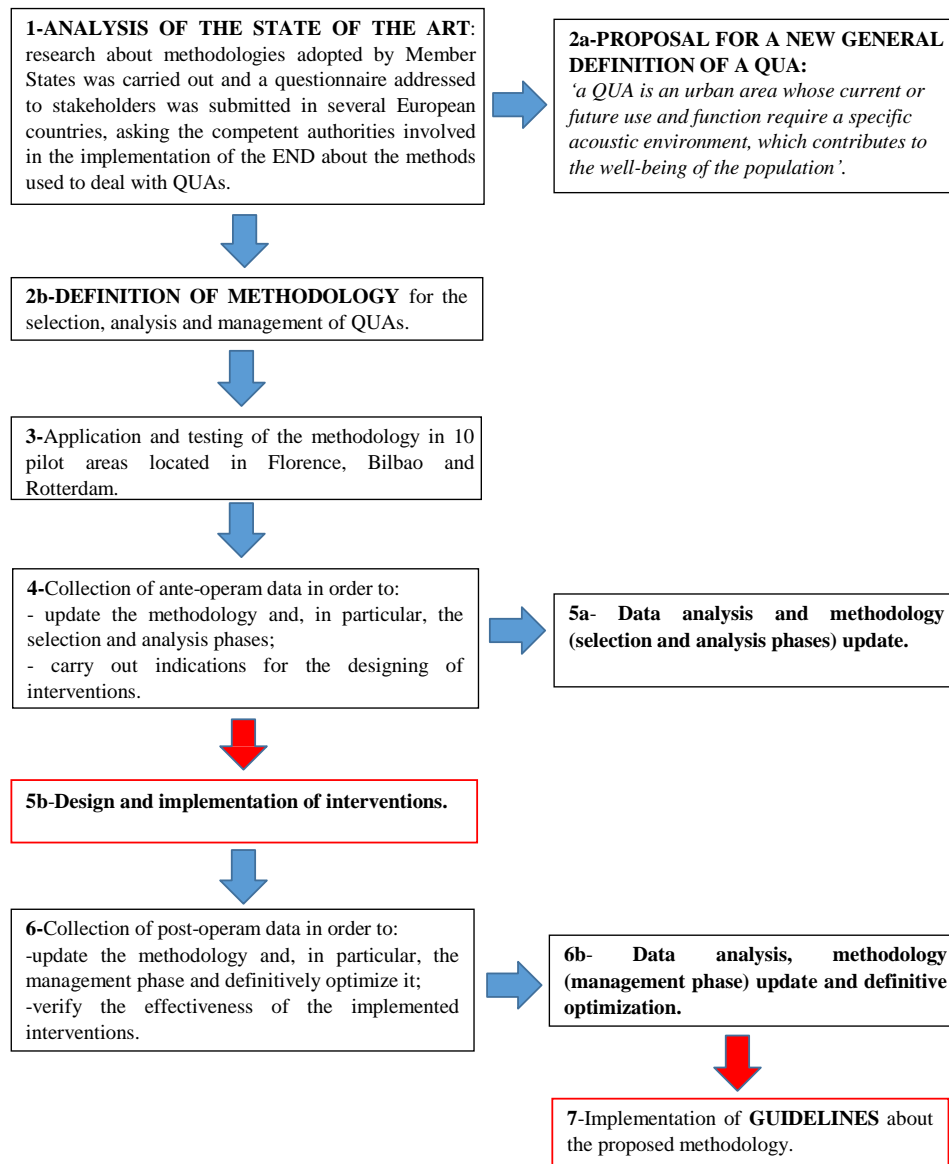


Chart 1: Operative phases of the QUADMAP project.

ally quiet, and what action is needed to ensure that they effectively pursue the role for which they were designed.

At the Italian level, the Tuscany [6] and the Emilia-Romagna [7] regions and the LIFE+2008 HUSH project [8] have introduced some criteria for identifying QUAs, but they do not provide indications for the analysis and management phases. Concerning the Spanish National regulation [9], it refers to a criterion that only addresses the QUAs selection phase.

The main aim of QUADMAP (QUIet Areas Definition and Management in Action Plans) Project was to propose a solution to overcome the lack of harmonized methodologies for QUAs.

The Project is highly demonstrative since the proposed methodology has been tested in a number of pilot areas in Florence (Italy), Bilbao (Spain) and Rotterdam (The Netherlands). The Project started on 1st September 2011 and was concluded after three and a half years.

2 Methods

In Chart 1 a schematic description of the main actions performed during the Project to develop the methodology is shown.

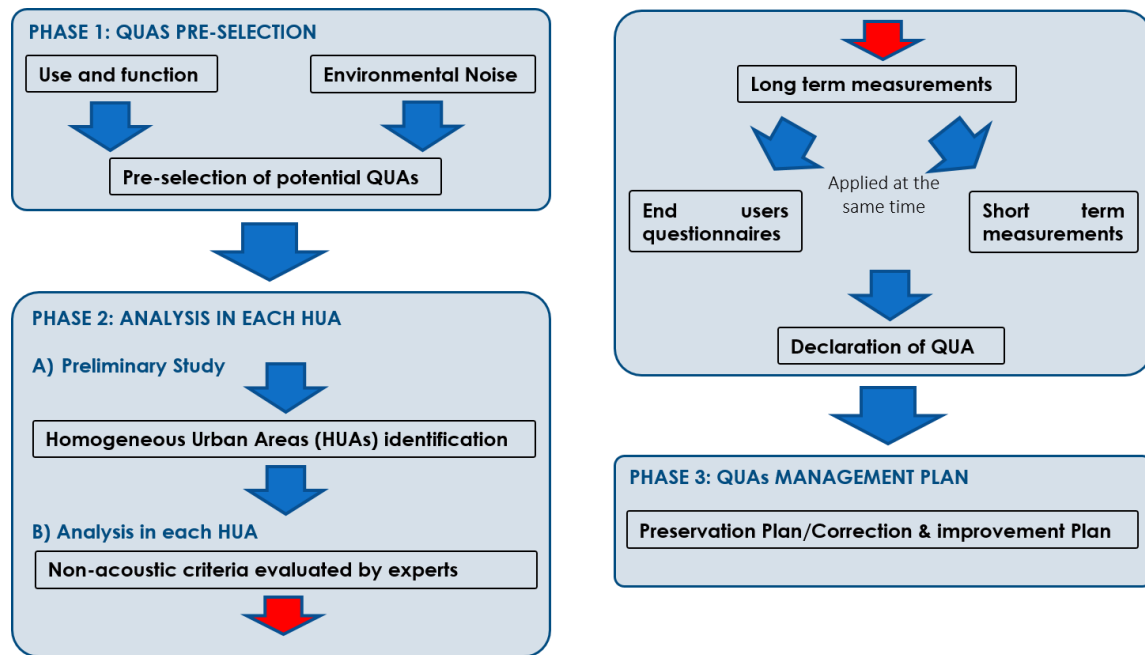


Figure 1: QUADMAP methodology for QUAS selection, analysis and management.

In Figure 1 the final version of the methodology is summarized in a flowchart and each phase is briefly described in the text. A further and more technical description of the methodology and of data specifications have been provided in previous publications [10–14].

Phase 1: QUAs selection

Two main variables are indicated for the selection phase: use and function of the area (variable 1) and noise level (variable 2) provided by the noise maps required by the END, to be compared to a threshold established by each Member State (a recommended threshold is provided by the methodology according to the State of the Art). As a result, an area can be pre-selected as a potential QUA not necessarily because its noise levels are lower than the threshold, but also because of the category of its land use in general urban planning or the area's (current) function: social relationships, conversation, resting, reading, playground, sport activities, leisure activities, etc.

Phase 2: QUAs analysis

Firstly, a preliminary study is carried out in order to understand if the area should be divided in Homogeneous Urban Areas (HUAs): smaller areas evaluated as uniform according to the landscape, use and distance from noise sources.

Then in each HUA some non-acoustic factors (e.g., natural elements, cleanliness, safety, etc.) are examined and evaluated by experts (e.g. technicians of municipality). Long-term measurements (i.e. minimal duration 1 week) should be carried out in each QUA to detail the noise maps in the specific studied areas, to collect acoustic information about the variability of sound levels over time in the area and to assess the impact of the acoustical interventions. Then, at the same time a questionnaire is submitted to the users of the area, to collect information about their general and specifically acoustic perception and short term measurements (same duration of interviews) are performed. As a conclusion for the analysis phase, the area is evaluated as already quiet (e.g. no criticalities are detected) or only potentially quiet (e.g. some criticalities are present at least in one of the performed analysis).

Phase 3: QUAs management

Different management goals are proposed, depending on whether the selected areas are defined as actually quiet (in order to preserve the area, to increase their value or to promote their use) or only potentially quiet from the analysis phase (interventions are designed in order to improve the quality in the QUAs and possibly to solve all the highlighted criticalities).

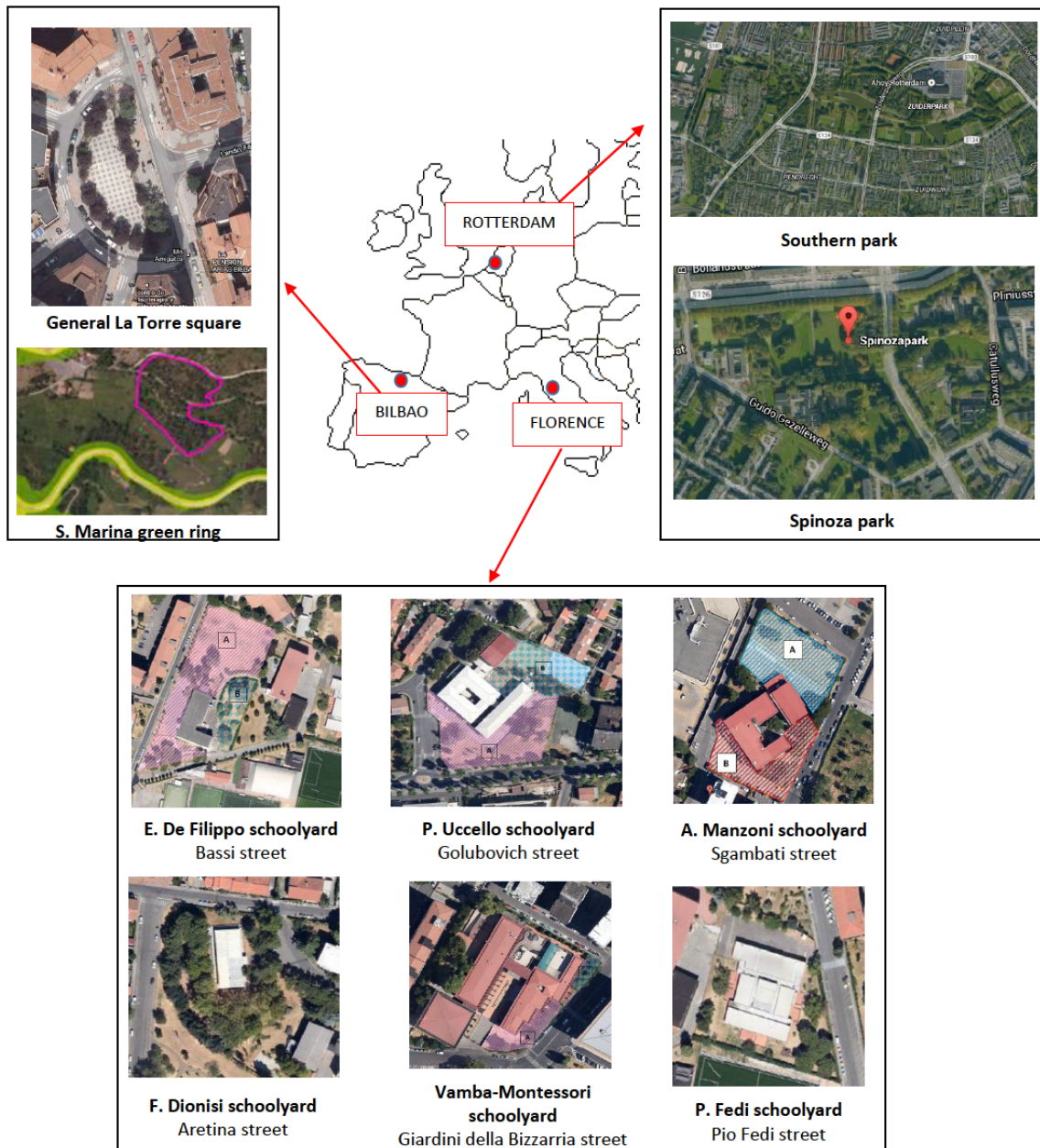


Figure 2: Pilot cases.

Pilot areas

Figure 2 shows the pilot cases object of the methodology testing procedure: six schoolyards in Florence (Italy), a square and a peri-urban green ring in Bilbao (Spain) and two public parks in Rotterdam (The Netherlands).

3 Results

Results achieved by the QUADMAP project include:

(1) A guideline for the selection, analysis and management of QAs

The main benefit of the Project consists of the guideline [13], available on the Project website.

It provides applicative examples and practical instruction tools, which will reduce the learning curve, minimizing the time required for the adoption of the new methodology, mainly in those countries where a methodology is still missing. The spreading of a harmonized approach will lead to a completely new monitoring tool, currently miss-



Figure 3: Examples of carried out interventions (low noise paving, noise barriers, seats) in the pilot areas.

ing due to the fragmented state of existent methodologies. In other terms, it will be possible for EU to monitor the QUAs management among the different Member States, based on common QUAs tools and indicators proposed in the guideline.

(2) A database on QUAs

Another important benefit comes from the data collected during the Project, which will be publicly available on the Project website, as examples for further application of the methodology in other contexts.

(3) Interventions implemented in the pilot areas

The Project has obtained specific important benefits referring to the pilot areas. After the application of the QUADMAP method, in most of pilot areas acoustic and non-acoustic interventions were defined and implemented, as reported in Table 1 and shown in Figure 3.

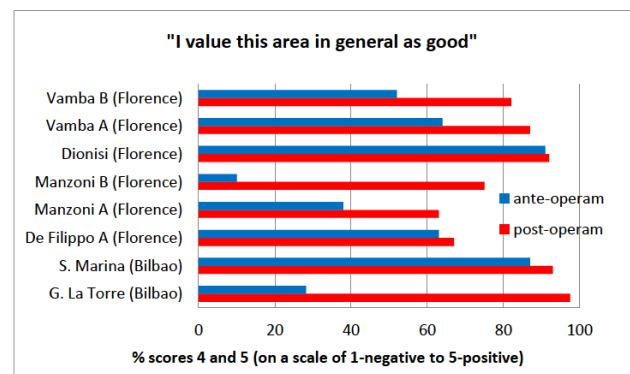


Chart 2: Citizens perception immediately after the interventions realization in Florence (for each area the letter A or B refers to the identified HUAs) and Bilbao.

(4) Reduction of noise levels and/or increase of positive events/resolution of criticalities

In general, benefits achieved in all cases consist of an improvement in the evaluation from experts after the intervention and in increasing citizens' satisfaction, as shown in Chart 2, with reference to the pilot cases located in Florence and Bilbao.

Table 1: Interventions carried out in the pilot cases.

Pilot area	Acoustic interventions implemented	Non Acoustic interventions implemented
Vamba/Montessori schoolyard	Noise barrier.	A part of the barrier is green type. A wooden platform in the garden area protected by the barrier has been designed.
Dionisi Schoolyard	Noise barrier.	Blackboards integrated into the internal side of the barrier.
Manzoni Schoolyard	Noise barrier.	Five trees, 30 concrete cube seats.
De Filippo Schoolyard	Noise barrier.	Four trees, 20 concrete cube seats; two sound games.
P. Fedi schoolyard	Additional road signs containing the prescribed speed limit of 30 km/h (minor intervention).	/
P. Uccello schoolyard	Noise barrier.	Seats made up of concrete cubes of size 45 × 45 × 45 cm with anti-graffiti treatment.
S. Marina green corridor	/	Selective tree thinning of non-autochthonous plants (<i>Pinus Pinaste</i>).
G. La Torre square	Urban barrier for traffic noise combined with a fountain (that creates background water sound and water sound events related with jets), improvement of traffic flow, give priority to pedestrian, increasing greenery (developing small hills)	Increasing the pedestrian accessibility, creating visual permeability, improving the construction quality in materials and services (putting 43 trees in the area and increasing the presence of benches), increasing the resting areas in the square and the area for greenery, increasing the acoustic comfort in the area (pleasant sounds coming from urban furniture with vertical water dispensers).
Southern park	Low noise paving.	/
Spinoza park	Low noise paving.	/

Table 2: Noise levels (LAeq) and noise events evaluated in General La Torre square for the post-operam phase (in brackets the difference between the post and the ante-operam scenario).

	Morning		Evening	
	11:00–11:30	11:30–12:00	18:00–18:30	18:30–19:00
LAeq	64 dBA (-3)	66 dBA (+4)	64 dBA (0)	66 dBA (+4)
Negative events (<i>e.g.</i> traffic noise)	2 (-4)	2 (-4)	2 (-7)	0 (-2)
Positive events (<i>e.g.</i> birds singing, sound of water, children's voices)	0	0	0	4 (+4)

Table 3: Expert analysis-ante operam scenario for the pilot cases selected in Florence (Dionisi schoolyard).





Criteria	Description	Parameters	Rating	Dionisi Schoolyard	Input to define possible solutions
Safety	Evaluation of safety by observation from experts	Dangerous zone (robberies, attacks or accidents from official statistics in the area)			Propose interventions to improve safety. 04: TO CLOSE THE GARDEN WITH A BARRIER
		Not guarded spaces or dark zones without lighting			
		Guarded and lighted spaces			

Table 4: Expert analysis-post operam scenario for the pilot cases selected in Florence (Dionisi schoolyard).





Criteria	Description	Parameters	Rating	Dionisi Schoolyard	Input to define possible solutions
Safety	Evaluation of safety by observation from experts	Dangerous zone (robberies, attacks or accidents from official statistics in the area)			/
		Not guarded spaces or dark zones without lighting			
		Guarded and lighted spaces			

Table 5: Evaluation of the CBI in the pilot areas located in Florence.

Pilot case	Interventions' cost [€]	IP ante-IP post	CBI INDEX
De Filippo	60.110,78	3276,3	18,3
Manzoni	127.248,91	5194,3	24,5
Dionisi	81.474,49	831,6	98
Montessori-Vamba	141.354,17	3174	44,5

Referring to the acoustic benefits, the implemented interventions significantly reduce noise levels in some cases where noise barriers take place. In other cases, the noise levels have been only slightly reduced or not at all reduced. For example, in the pilot cases located in Florence, according to short term measurements associated with questionnaires, average noise levels were lower during the post-operam surveys, with benefits up to 8 dB in terms of LAeq in the shadow zone behind the barrier.

In the General La Torre square, referring to the periods in which ante and post-operam questionnaires have been submitted, noise levels (LAeq) are even slightly increased (2–3 dBA) after the interventions had been realized. This fact in general can be explained according to the typologies of interventions realized in General La Torre square where they were not specifically aimed to reduce noise levels as to modify dominant sound sources and increase positive events. After the interventions' had been realized, the background sound (LAeq) and the number of positive event increased. At the same time, the urban barrier has masked the traffic noise, reducing the presence of negative events (see Table 2).

Finally, regarding the analysis carried out by experts, depicted criticalities have been solved by the end of the Project. As an example, from the comparison of results concerning non-acoustic principal factors during the ante and the post-operam phase, it can be seen that the criticality emerged for the Dionisi school (Florence) concerning safety (see Table 3) was solved during the post-operam phase (see Table 4).

(5) Cost-benefit index

In the pilot areas located in Florence in which a noise level reduction was obtained, a cost-benefit index has been assessed. In particular, a Cost Benefit Index (CBI), similar to the one proposed by the LIFE+NADIA project [15], has been developed. Variables considered by the CBI index are the interventions' costs and the Priority Index (IP) evaluated both for the ante and the post-operam phase.

$$CBI = \frac{\text{inventor's cost}}{IP_{\text{ante-operam}} - IP_{\text{post-operam}}}$$

$IP = R \cdot k \cdot (L_{obs} - L_{im})$ where:

L_{obs} = average noise level in the QUA (determined by using LAeq evaluated in the opening time of the QUA), ante-operam/post-operam scenario [dBA]

$L_{im} = 55$ [dBA] (noise indicator Lday, as further defined in Annex I of Directive 2002/49/EC [1])

$IP = 0$ if $(L_{obs} - L_{im}) < 0$

R = number of users

$k = 1$ or 3 (3 when QUA is a schoolyard)

As shown in the previous equation, lower CBI values mean a better cost/benefit compromise.

From results obtained (see Table 5), it can be noticed that values of the CBI Index obtained for De Filippo, Manzoni and Montessori-Vamba schools are quite similar and low. Regarding the Dionisi school, a higher value of the CBI Index has been found, but this is reasonably due to the lower number of users and to the lower efficacy requested

Table 6: Synthesis of QUAs definitions and selection criteria used in Italy and Spain.

Regulation/ Guideline	Quiet Urban Area definition	Criteria for the QUAs selection
END	"an area, delimited by the competent authority, for instance which is not exposed to a value of L_{den} or of another appropriate noise indicator greater than a certain value set by the Member State, from any noise source".	/
Regional regulation of Tuscany Region, Italy [6]	See National Decree D.Lgs. 194/2005 transposing the END.	<ul style="list-style-type: none"> – Identification criteria based on the municipality Acoustical Classification Plan (PCA) – (area belonging to the III class at most, L_{day} up to 60 dB(A) are permitted for areas in III class); – Extension of the area less than 1000 m², which constitutes at least 50% of the land of each area; – L_{day} level lower or equal to 55 dB(A); – NA70 indicator lower than 12 in daily time period.
Guidelines of the HUSH project [8]	See National Decree D.Lgs. 194/2005 transposing the END.	<p>Approach n°1 – based on the allocation of the QUA referring to specific destination of use (schoolyards, public parks, squares, green areas, etc.) and the comparison with the L_{day} limit values for the assigned acoustic class of the PCA;</p> <p>Approach n°2 - spatial criteria, descriptors and limit values recognized in the Regional Regulation of Tuscany Region.</p>
Guidelines of Emilia-Romagna Region, Italy [7]	See National Decree D.Lgs. 194/2005 transposing the END.	<p>Approach n°1 – area belonging to the I class of the PCA (L_{day} up to 50 dB(A) are permitted for areas in I class);</p> <p>Approach n°2 – approach adopted by the city of Hamburg (only a very general description is provided in the guidelines);</p> <p>Approach n°3 – soundscape (only a very general description is provided in the guidelines).</p>
National regulation of Spain [9]	See National Decree 1367/2007 transposing the END.	<p>$L_{day}/L_{evening}/L_{night}$ 5 dBA below the noise quality reference fixed for the areas depending on their use. The aim is to try to preserve the better sound quality that is compatible with sustainable development.</p>

$L_{day}/L_{evening}/L_{night}$ (day/evening/night noise indicators defined by Directive 2002/49/EC, as further defined in Annex I of Directive 2002/49/EC [1])

NA70 – number of noise events over 70 dB(A) in terms of L_{Amax} occurred in the daily time period, as further defined in [16]

to the intervention. In fact, in this pilot case the main reason to build up the barrier was safety instead of noise.

(6) Innovative character of the Project

In order to highlight the benefit of the methodology proposed by QUADMAP project, in Table 6 an overview of the main legislations and regulations has been made with reference to the QUAs selection phase adopted in the Italian and Spanish legislative and operative context.

Referring to the analysis and management phases, no substantial contributions other than QUADMAP project have been given so far. Consequently, QUADMAP project appears as a very innovative and necessary tool according to these phases.

4 Conclusions

The definition of QUA provided by the EU Directive 49/2002/EC on Environmental Noise (END) seems extremely vague and does not provide usable procedures to be applied in each country.

The main aim of the QUADMAP project was to propose a complete, harmonized and validated methodology aimed at QUAs, applicable at the European level, but at the same time adaptable to each Member State and QUA typology. The proposed method for selecting, analyzing and managing QUAs has been developed in the QUADMAP project and successfully tested in ten pilot areas. In addition, with its flexibility, the methodology is also easily replicable in other urban environments and has also proved to be applicable for designing QUAs or for integrating a “quietness” element into local authorities’ urban planning and development policies.

One of the methodology’s innovative aspects is the involvement of the public in planning and designing noise abatement intervention. In fact, interviews should always be carried out, in order to solicit for users’ opinions about the typical aspects of each QUA and to obtain suggestions for the type of intervention to be implemented.

About the difficulties faced during the project, the main one arose versus the use of a unique end-users questionnaire format in all QUAs. In fact, some problems arose in the pilot cases of Florence where schools were considered, due to the young age of most of the people interviewed. It was quite difficult to explain some of the questions asked, especially to students of primary schools, with particular reference to those concerning the sense of “perception”. As a proposed solution, the final version of end-users questionnaire included in the guidelines [13] has been revised to introduce the possibility of skipping some questions, depending on the age of interviewees. As the main deliverable of the project, the proposed methodology and related tools for the selection, analysis and management of QUAs, have been summarized into comprehensive guidelines at the beginning of 2015 [13]. This document manages to help stakeholders, competent authorities and interested parties to understand the END’s requirements with respect to QUAs and to recommend

a valid and easily applicable methodology. In addition, these guidelines also suggest possible answers to some research questions posed in the guideline on quiet areas, published by EEA [5], in particular the need of combining users’ acoustic perception of a QUA with their general opinion of the area. Moreover, among the after-LIFE activities of the Project, it is foreseen to share knowledge with other European projects and with EUROCITIES, the network of major European cities. As a significant example, the project’s guidelines have been sent to EUROCITIES office and they will distribute this to all European cities being member of EUROCITIES, supporting them in the methodology application.

Acknowledgement: Authors would like to thank the European Commission for contributing to this Project considering and co-financing it into the LIFE+2010 Financial Programme.

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