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SOUNDSCAPE & LAND USES MANAGEMENT AS COMPREHENSIVE ENVIRONMENTAL PROTECTION ACTION POLICY TOOL WITHIN THE STRATEGIC ENVIRONMENTAL NOISE MAPPING IN GREECE

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Environmental Noise Mapping, as per the relevant 2002/49/EC Directive, is an obligation of all European Union (EU) member states. In the framework of this action in Greece and Cyprus within the Action Noise Plans assessment and evaluation, various strategies aiming to reduce noise exposure of residents, introduce, and preserve "quiet zones" were analyzed and proposed. In this framework, additional tools - apart the measurement and modelling of environmental noise levels - were introduced, as per qualitative surveys on the sound perception by the residents and several analyses of the urban and architectural tissue and also land use management action policy tools. For several urban agglomerations and international airports, selected urban areas were assessed, based on their proximity to transportation infrastructures (main road network, industrial harbour facilities and both regional and intercity train network) and also to the diversity of their urban typologies (residential district, downtown areas. Sociological surveys on sound and noise perception were also implemented using opened questionnaires. In this paper, we aim to assess and compare - for various cases in both countries - soundscape & land uses qualitative criteria analysis. This approach aims to evaluate their possible implementation as comprehensive Environmental Protection Action Policy Tools, within the 2002/49/EC directive, by developing interesting qualitative approaches to further manage and rehabilitate the sound comfort for the inhabitants, and therefore improving the built soundscape with emphasis to South-European countries where the style of life is strongly connected with open air activities.

1. Introduction

Environmental Noise Mapping, as per the relevant 2002/49/EC Directive, is an obligation of all European Union (EU) member states. In this framework, additional tools - apart the measurement and modelling of environmental noise levels - were introduced, as per qualitative surveys on the sound perception by the residents and several analyses of the urban and architectural tissue and also land use management action policy tools. Indeed, despite the introduction of strategic noise maps and the choice of a single quantifiable indicator (L_{den}), a number of research teams, but also practitioners (town planners, acousticians, architects) are also questioning the qualities of the sound environments that they would produce. The vast majority of them introduce qualitative dimensions in their analysis (by introducing the concept of soundscape) and trying to understand why significant parts of the population like or dislike the sound qualities of their environment. In other words, we believe that the presentation of such results in a project approach does not help the emergence of innovative solutions

in terms of sound qualities and noise action plans. This raises questions, particularly on a certain uniformity of sound environments of the new districts and the danger it poses to their sustainability: a neutral area with no emergence, without events, which displeases nobody but that do not please anyone. Or how the sound environment can participate in the uniqueness of a neighbourhood?

Our proposal must take account of this fact and propose tools, which on the existing or new district are used to guide the sound qualities of a neighbourhood towards a sustainable development because they contribute to user's comfort. However, we must ensure that these sound qualities also create remarkable situations, unique, special, to ensure its attractiveness and sustainability over the years. Several municipalities in Greece (Volos, Larissa, Chania, Heraklion, Corfu, Agrinio and Thessaloniki) chose to analyse also the sound qualities of the soundscape of specific neighbourhoods (urban area or U.A.) in order to include recommendations for the design of the cities soundscape that complement the conventional noise mitigations. The general principle of this approach is to articulate quantitative data (measurements, acoustic simulations, urban forms, topography, and traffic model) to qualitative data (type of sources, interviews, reports of perception) through editing quantitative and qualitative maps [1]. The aim of such work is to propose possible changes to competent authorities for a diminution of the number of noisy areas but also possible evolutions for the production of sustainable sound environment in space and in time

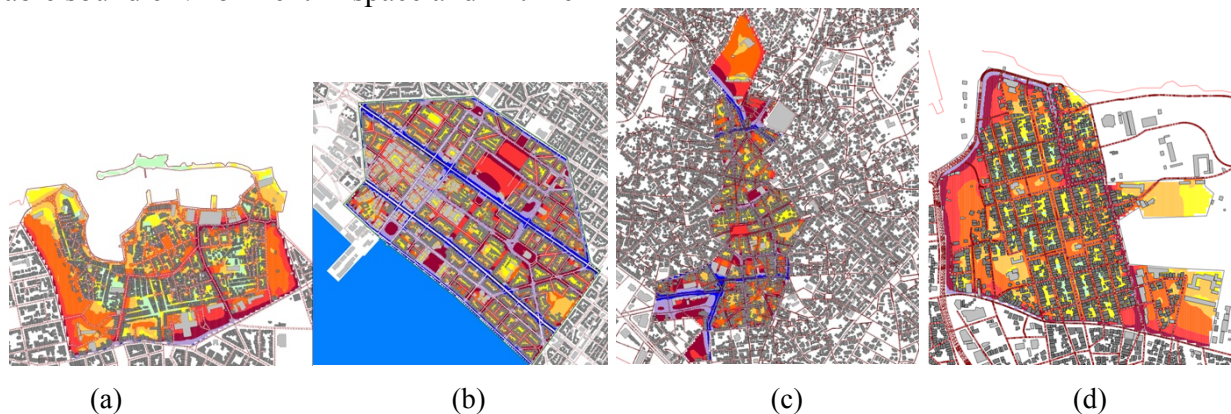


Figure 1: S.N.M (road) of (a) Chania urban centre and port (2013), (b) Thessaloniki Historical City centre, (c) Agrinio city centre and Alikarnassos district in Heraklion U.A., Greece, Noise index L_{den} .

2. From Noise mitigation to soundscape design

Environmental noise mapping as defined in Directive 2002/49/EC was introduced in the Greek legal framework by Joint Ministerial Decision (JMD) 13586/724/B/FEK/384/28.3.2006 (Harmonization of European Directive 2002/49/EC "for the assessment and management of environmental noise" in Greek Law). The Directive 2002/49/EC on the assessment and management of environmental noise, apart from the introduction and management of 'environmental noise', aims to define a common approach intended to avoid, prevent or reduce on prioritized basis the harmful effects, including annoyance due to environmental noise exposure. The purpose of this Directive is also to provide a basis for developing Community measures to reduce noise emitted by the major sources, in particular road vehicles and relative infrastructure, rail, outdoor and industrial equipment and mobile machinery. It covers the issue of environmental noise, which is perceived by citizens inside their houses and around them, in relatively quiet areas of an urban area or the countryside, within hospitals and around them, in schools and around them, as well as inside other buildings. The Directive does not cover noise generated by an individual, nor the noise, which is perceived within the means of transport, or caused by domestic activities, entertainment, neighbourhood practices or in the workplace. One of the study purposes is the projection of the environmental noise problem at national level, the adequate information of the local authorities and the citizens, the provision of the appropriate data to the European Commission as well as the utilization of the data for the planning of anti noise policies and measures in the framework of the implementation and fulfilment of the relevant END obligations.

The modelling of the traffic and aircraft noise, in the framework of the current study assures the implementation of EC RECOMMENDATION of 6th Aug 2003, and the Joint Ministerial Decision 13586/724/B/FEK/384/28.3.2006 (Harmonization of European Directive 2002/49/EC "for the assessment and management of environmental noise" in Greek Law).

According to article 6 and the Annex II of the END, the temporary methods of computation for defining the indices L_{den} & L_{night} for the noise due to traffic and aircraft noise are recommended to the member states that do not have a national method of computation or to the member states that wish to convert to a different computation method. In the framework of the environmental noise mapping, for the road traffic noise, the national French method «NMPB-Routes-96 (SETRA-CERTU-LCPC-CSTB)» was taken into consideration, as it is presented in the «*Article du 5 mai 1995 relatif au bruit des infrastructures routieres, Journal Officiel du 10 mai 1995, Article 6*» - «XPS 31-133». For aircraft noise, it was taken into consideration the methodology «ECAC.CEAC Doc. 29 / Report on Standard Method of Computing Noise Contours around Civil Airports, 1997». The study includes:

- (a) general description of the agglomeration,
- (b) characterization of their surroundings: agglomerations, villages, countryside or otherwise, information on land uses,
- (c) other major noise sources,
- (d) noise control programs carried out in the past and measures against noise and
- (e) applied methods of calculation and measurement.

The study estimates the total number of people (in hundreds) living outside agglomerations living in dwellings exposed to each of the following bands of values of L_{den} (in dB), at a height of four meters above the ground on the most exposed facade: 55-59, 60 - 64, 65-69, 70-74, > 75 or if otherwise arise under the terms of the order. It also estimates the total number of people (in hundreds) living outside agglomerations living in dwellings exposed to each of the following bands of values of L_{night} (in dB), at a height of four meters above the ground on the most exposed facade: 50-54, 55 - 59, 60-64, 65-69, > 70. In addition, it should be stated, where appropriate data and appropriate, how many persons in the above categories live in dwellings that have special insulation against the noise and quiet facade.

The estimated total number of dwellings (in hundreds) and the estimated total number of people (in hundreds) living in each of these areas. These numbers should include agglomerations. The relevant studies ends with the Noise Action Plan introducing the necessary mitigation measures.

In this case special recommendations for soundscape design were introduced in the S.N.M. and N.A.P.'s of several selected urban areas (U.A.) for selected districts within.

3. The Selected Medium Urban Areas (U.A.) in Greece

From 2012 to 2015, this methodology was introduced in 7 medium urban areas in Greece: Volos and Larissa (2012), Chania and Heraklion on the Crete island (2013), Corfu and Agrinio (2104), Thessaloniki in 2015 ([1], [2], [3]).

Table 1, hereafter, presents the selected medium urban areas studied within the frame of the European directive EU/2002/49, described by their surface, their number of buildings included introduced in the 3D model and also by the number of Point of Interest (POI for sensitive buildings dedicated to health, education and religions) and finally, by also the type of noise that has to be considered in the study (road, industry, train and air traffic).

Table 1: General description of the selected medium urban areas in Greece.

| A/A | Urban areas | Km ² | Buildings Numbers (POI Numbers) | Road + industrial | Train | Plane |
|-----|----------------------------|-----------------|---------------------------------|-------------------|-------|-------|
| 1 | Volos | 13 410 | 26 281(201) | x | x | - |
| 2 | Larissa | 19 364 | 25 036 (172) | x | x | - |
| 3 | Chania | 10 286 | 16 861 (130) | x | - | - |
| 4 | Heraklion | 26 022 | 41 615 (383) | x | - | x |
| 5 | Corfu | 9 130 | 7524 (190) | x | - | x |
| 6 | Agrinio | 9 582 | 12 177 (148) | x | - | - |
| 7 | Thessaloniki (city centre) | 21 531 | 37614 (321) | x | x | - |

These urban areas are all different and but they share several acoustic challenges regarding the environmental noise directive and regarding the soundscape management:

- Volos, Corfu, Chania, Heraklion and Thessaloniki are cities nearby the sea so, they have to deal with the fact that the ring road cannot get around the city area.
- Chania, Corfu, are two international touristic destinations and expectations regarding noise and sound environment are quite different for inhabitants and tourists.
- Volos, Heraklion, Thessaloniki have traditional activities linked to their touristic commercial and industrial harbours.
- Agrinio, Larissa, Heraklion, Corfu are located close to military and/or civil airports. Heraklion and Corfu have international airplanes traffic.
- Thessaloniki (city centre) is waiting for a huge change in its way to organise its public transports by the opening of the first line of the Metro within the next years.

Table 2: District selected within the 7 U.A. in the frame of the EU 2002/49.

| U.A. | Inner District | Selection Reasons - Acoustic challenges |
|----------------------------|------------------------------|--|
| Volos | Fitokou | New residential areas close to ring road with an educational building (University). |
| | Iolkou | Old and dense residential areas crossed by the ring road |
| | Karagatz | New residential area close to ring road in development |
| | Old city | Mix of commercial, craft, leisure, night life and residential building in an area located close to the industrial port. |
| | The seafront | Impact of pedestrianization of several street sections. |
| Larissa | Echekratida | Residential area nearby the railways |
| | Alkazar Park | Large urban park close to main roads of Larissa with traffic |
| Chania | Old City | Historical and touristic city centre in front of sea with a minimum of car traffic |
| Herakleion | Alikarnassos | Residential and commercial area located just next to the international airport "Nikos Kazantzakis" |
| Corfu | Kanoni | Residential and touristic area located just next to the international airport "Ioannis Kapodistrias" |
| Agrinio | Centre | Historical city centre of the city crossed by major roads |
| Thessaloniki (city centre) | Agia Sofia | Commercial and residential area in Thessaloniki city centre in rebuilding after international architectural competition. |
| | Freedom sq. | Business and residential area in the entrance of Thessaloniki on sea side after international architectural competition. |
| | Stock market square district | Reconstruction of the old traditional residential, commercial and night life district. |

All these reasons pushed the Greek authorities to focus their efforts on these urban agglomerations and mainly by providing general recommendations for the sound environment qualities in specific key sectors as described as follows:

These districts were chosen because they were representing key points regarding the management of sound environment: they could be exposed or crossed by significant noise sources (traffic, industrial areas, airports) but more importantly they were representing areas tests for the city and its future. Work on these areas helps to develop recommendations for these specific neighbourhoods but often these recommendations concern the entire metropolitan area (changing road traffic or the relocation of an airport, introducing soft modes of mobility) but they are also generalizable to similar neighbourhoods.

3.1 Strategic Noise Maps (S.N.M.)

Strategic Noise Mapping (S.N.M.) as per the European Directive 2002/49/EC e.g. a map designed for the global assessment of noise exposure in a given urban agglomeration due to different environmental noise sources or for overall predictions is now mandatory for all Urban Agglomerations of more than 100.000 inhabitants (Round II), and must be in compliance with the ANNEX IV of the Directive. The execution of the relevant S.N.M.'s, for the above medium urban agglomerations, was based in the collection and processing, with cohesion and compatibility, of a large number of inter-connected data of a complete Digital Terrain Model (Geographical, Topographical, Urban & Land Use, Census and Population, Traffic). The execution of the prediction calculations regarding the noise levels for both present and future conditions scenarios was secured by using a specialized software (CadnaA) in which the Digital Geometrical and Functional model of the area has been suitably imported. A full GIS database was constructed in order to manage, analyse and graphically present all geo-referenced data (i.e. data coupled with a spatial reference). These S.N.M.'s provide the possibility to focus and edit local urban areas at a smaller such as the central district and the Old Port S.N.M. within the urban area agglomeration of Chania in Crete Island (a), the historical city centre of Thessaloniki (b), the city centre of Agrinio (c) and the Alikarnossos neighbourhood district at Heraklion U.A (see fig.1)

At this scale, it is possible to analyse the given district in a street by street level, or even building blocks by buildings blocks and access the relation between the urban form and the noise propagation of noise main sources indicating among other parameters (a) the absolute value of acoustic criteria in all the public spaces of the selected area, and (b) the relative value of these noise criteria as needed for the complete soundscape analysis integrating ground topography and 3D model of buildings. In parallel of the S.N.M. several type of maps ere introduced in order to understand better, the appearance and the propagation conditions of the main sound sources in the neighbourhood.

3.2 Qualitative urban and sound maps

Several qualitative maps are also produced in order to complement the noise strategic noise maps and prepare the noise action plan and the soundscape design guidelines.

3.2.1 Urban typology map

Within this type of map, the sections of the urban space in which sounds propagate are described: U-shaped or L-shaped section, open road are usually the 3 categories uses for this map. The interest of such representation is to simply represent on a layer of the map the third dimension that interest acoustic propagation conditions of sounds.

3.2.2 Spatio-acoustic map

This map shows the urban forms based on the potential acoustic effects (as acoustic filters, acoustic fence, reserves of silence, sound territories, urban acoustic room, sound rhythms...) created by the urban forms. *In situ* analyses (sound recordings, observations and interviews), combined to strategic noise mapping are able to show that the topography of the district, and the given forms of the existing buildings creates easily identifiable sound effects when someone walks through the district. In a

global analysis of the soundscapes qualities is important to show clearly in an appropriate map such potentials of the existing urban form.

3.2.3 Map of the predominant uses

This type of map shows the most prevalent uses of public space and buildings: pedestrian streets and alleys, street for both pedestrians and cars circulation in reduce speed, low traffic road, heavy traffic road, shops, offices, cultural, educational, health or religious buildings, etc.

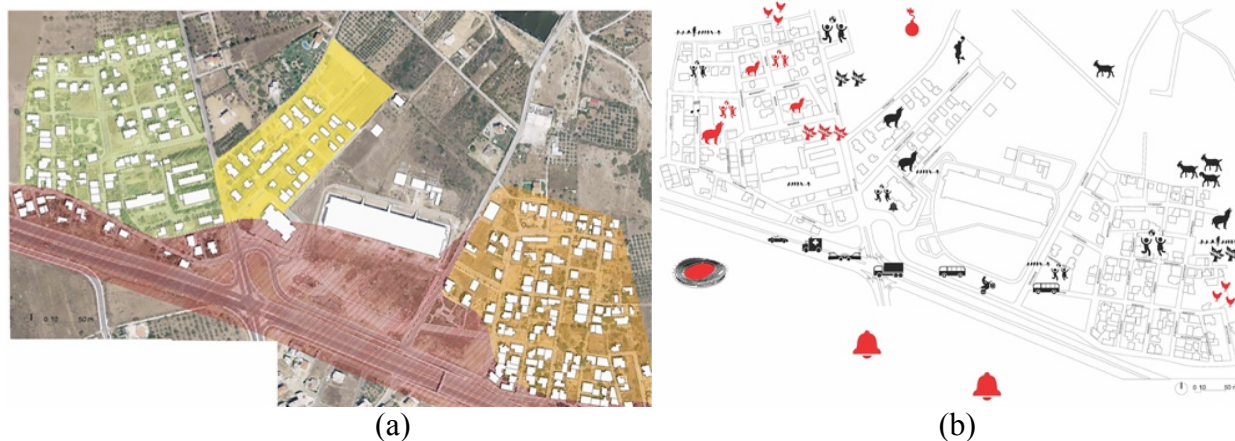


Figure 2: Volos U.A.: (a) Sound identity map and (b), Sound signals and sound markers of the district, 2012.

3.2.4 Sound signals and sound marks Map

This part of the analysis is very important in order to understand how the area's population is living in the existing acoustic environment and how they produce, use and finally evaluate, and the sounds of their everyday life. This assessment approach use interviews that are completed within the local residential population on the basis of a semi-directive questionnaires. it is clear that signals and/or sound events are mentioned mainly by the locals, related to the activities of the district, even produced outside the district boundaries but clearly perceived in the research area. All these sounds are audible indications of the sound identity of the given urban area, even if sometimes, some of them can only be heard within the relevant boundaries.

3.2.5 Sound identities Map

The compilation of all the available interviews can bring out specific inner areas of the district, rather homogeneous, in terms of how sounds are produced and heard within the district. These are the identities that help to describe - on an average level - how, in a specific area, the people perceive and produce several sounds. For each of them, we try to give a name or a description of the urban area that may characterize its sound environment. This type of map actually aims to summarize in a simplified all that the interviews have emerged.

4. Noise Action Plans (N.A.P.) and Sound Design Guidelines (S.D.G.).

Following the mains results presented in the chapter above, several hypotheses are possible, and in collaboration with the local authorities, a series of simulations is available in order to evaluate the impact of proposed important actions and modifications especially regarding the existing status of both traffic and industrial noise sources.

Table 3 hereafter presents the relative main hypothesis produced for each of the selected Urban Agglomerations (U.A.).

Table 3: Noise Action Plan (N.A.P.) - A Brief Description by district within the selected medium U.A.

| Urban Area | Inner Districts | Noise Action Plan – A brief description |
|----------------------------|---------------------------|--|
| Volos | Fitokou, Iolkou, Karagatz | Noise barriers implementation |
| | Old city (Palia) | Traffic regulation by introduction 2 round about in the entrance of the district |
| | The Seafront | Avoiding car traffic and car parking an all the street sections between the 2 parallels mains streets of Volos (Dimitriados and Iasonos streets) |
| Larissa | Echekratida | Noise barriers implementation around the entrances of the underground tunnel that pass under the train rails. |
| | Alkazar Parc | Noise barriers implementation and asphalt quality modification |
| Chania | Old city centre & Port | Avoiding car traffic in several streets |
| Corfu | South East district | Operation Scenario 2018 and Relocation of Airport |
| Agrinio | City centre | Reducing traffic Speed |
| Heraklion | Alikarnassos | Relocation of the International airport |
| Thessaloniki (city centre) | Agia Sofia | Reducing and avoiding car traffic on all the axis. |
| | Freedom Sq. | Relocation of the public car parking |
| | Stock Market Sq. | Reducing the traffic by enlarging the sidewalks and by minimizing the parking slots. |

For each district an soundscape design guidelines is written in order to understand and preserve the sound identity of a given neighbourhood in a urban agglomeration, and unfolded on three distinct levels as analysed hereafter:

(a) **environmental dimension** level describing all physical, emission and propagation characteristics for all types of environmental sound sources;

(b) **Milieu dimension** level (social practices) which aims to describe all the uses that the area already offers and additionally all other that may be offered as well and then

(c) **the Soundscape dimension level**, characterizing the most aesthetic and symbolic links that residents establish with the particular sounds of their neighbourhood, highly valued by their aesthetic characteristics.

For example, in Chania, Crete, all the previous methodology has been applied to the historic centre. After measurements, simulation, in situ observation, interviews and editing the series of quantitative and qualitative maps, it is possible to give to authorities sound environment guideline as follow:

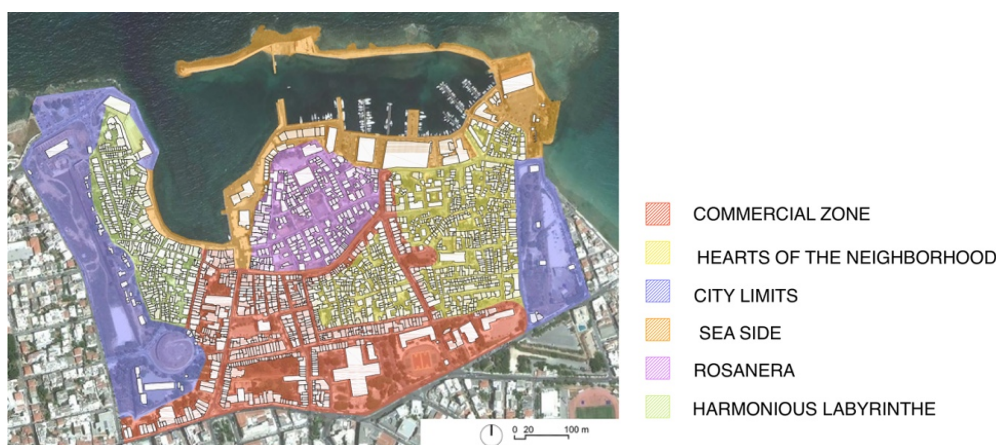


Figure 3: Sound identities map of the old city centre and port of Chania U.A., Crete, 2013.

Table 4: Extract of the N.A.P. and Soundscape design guidelines submitted for Chania U.A, 2013 [1].

| Identity | Environment | Milieu | Soundscape |
|-----------------|---|--|---|
| Commercial zone | <ul style="list-style-type: none"> • in the southern limits of the study area, but also at the squares we propose the regeneration of urban floor to enhance walking and reduce the use of motorised vehicles. • reduction road traffic noise by speed limitations. • enhancing the use of urban space dedicated to pedestrians, • construction of municipal and free peripheral parking lots. • connecting the parking lots to the historic centre by free public transports. | <ul style="list-style-type: none"> • maintenance of the actual uses of the spaces, • improve the presence of vegetation in the public spaces and introduction in the city centre of the water element. | <ul style="list-style-type: none"> • creation of different listening points of interest selected because of their specific sound atmosphere: commercial areas zone, close market, Conservatory, small parks, bazaar, etc. • improve the presence of vegetation in the public spaces and introduction in the city centre of the water element (public fountains) |

Therefore for each selected district, an action plan was proposed based on sound analysis identities and aiming: to preserve the qualities that are identified by residents for every case study area, allowing them to experienced further in the coming year, enhancing certain qualities observed in the field, to manage activities on the sites ensuring land use mixture establishing however their distinction, and finally to create sound aesthetic dimensions in order to promote soundscape listening.

5. Discussion

The European Directive was a great impulse to propose new methodologies to try to go beyond noise mitigation and try to orientate future soundscape sound qualities creation. The main goal of such methodology is to prevent of course urban areas from noises but also to create sustainable sound environment. We consider them sustainable because they have their own specificities – identities that makes them recognizable and appreciated by residents and visitors. They avoid standardization in sound environment qualities that might borrow people over the years and impulse innovation in noise mitigations, soundscape, urban and architectural design. Implementations of the guidelines need multidisciplinary approaches that gather public authorities, citizen, acousticians, city planners and architects. It's why mapping methodologies seems to be the more adequate in order to exchange information between the partners and also the best way to communicate expert analysis in between professional and citizens.

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