Empowering people on the assessment of the acoustic comfort of urban places: CITI-SENSE project

Itziar ASPURU1, Igone GARCÍA1, Karmele HERRANZ-PASCUAL1, Alvaro SANTANDER1

1 Tecnalia Research & Innovation. Spain

ABSTRACT

Tecnalia has applied the concept of citizen observatories to empower citizens in the assessment of acoustic comfort in public places. Tools and observation protocols are defined to allow citizens collecting simultaneous objective and subjective data of the sound environment in places of their city known by them. Previous works stated that criteria to define quiet areas should consider not only noise levels, but subjective data also, giving importance to the end-users perception of the area. This work was undertaken as part of the CITI-SENSE project and the solution was tested in a field demonstration, where 53 people were engaged to provide 137 observations in the city of Vitoria-Gasteiz, using environmental sensors connected to a smartphone.

Keywords: acoustic comfort, empowerment initiative, soundscape, APP

I-INCE Classification of Subjects Number: 56.3

1. INTRODUCTION

The assessment of potential quiet areas at our cities applies the soundscape approach, considering not only the acoustic characteristics of the urban areas, but also how their acoustic environment is perceived. QUADMAP project proposed Guidelines for the identification, selection, analysis and management of quiet urban areas. These Guidelines already defined a set of non-acoustic variables to be also considered in the management of quiet areas. On that sense, soundscape theory states the influence of the context (other physical characteristics of the space) on its assessment (1, 2, 3, 4). This makes very interesting to have tools that allow engaging citizens on collecting data in situ at the urban places at the same time that they report about their perceptions. Thus, it is of interest to investigate the applicability of the concept of Citizens Environmental Observatory to study the soundscape and to apply to the assessment of quiet areas in the city. It can facilitate having in situ observations made by citizens measuring simultaneously objective and subjective data.

This study was developed by Tecnalia in the framework of the CITI-SENSE project. It is a FP VII EU co-funded project that developed “citizens’ observatories” to empower citizens to contribute to and participate in environmental governance, to enable them to support and influence community and societal priorities and associated decision making (5, 6).

The project demonstrated the use of citizens’ observatories in three types of pilot case studies (named Empowerment Initiatives), focused on a range of services related to environmental issues of societal concern. One of those pilot case studies was referred to the assessment of the quality of public spaces and it was led by Tecnalia. Its aim was to empower citizens in the process of designing public places from an environmental point of view including comfort criteria. The specific objectives of the Empowerment Initiative of public places were:

- to allow citizens to collect and share quantitative and qualitative information related to the environment at existing public places, as well as their well-being in those places;
- to allow the city authorities to collect novel information about the ecosystem services provided in public places; and in this way,
- to support a dialogue between citizens and the local authorities to adapt their planning process to improve or preserve the environmental conditions in public spaces.

The solution designed and tested in the CITI-SENSE project involves (7):

- A kit of devices and software that allows doing the evaluations with enough accuracy to be considered in decision making process.
- A protocol to develop the observations. A training process is required to assure that the
observations are developed in the appropriated way.

2. PRODUCT TO ASSESS ACOUSTIC COMFORT

Citizen’s engagement on acoustic evaluations requires designing user-friendly products and enough accuracy and quality of obtained data to represent the acoustic comfort at the studied areas. Another important criterion to define and select the measurement system is to keep it as more affordable and accessible by citizen as possible to facilitate its use and reduce its cost.

Considering this approach (and taking into account other variables that are analyzed) the products and services developed to empower citizens in the evaluation process are the followings:

- Smartphone that integrates the CITI-SENSE app. Citizens would make observations using the smartphone as it is currently the most common portable device available. An external microphone is added to the smartphone.
- CITI-SENSE App: This App controls the sensors used to evaluate the most important environmental parameters in terms of comfort (acoustic and thermal comfort). The App also supports a questionnaire to collect in situ and during the measurements, the citizen’s perception of public places. It measures $L_{Aeq}$ values, detects noise events, asking the user to provide notes about them, and calculates the ESEI indicator, taking into account the information provided by the questionnaire (8). This indicator considers not only the traditional environmental acoustic indexes ($L_{Aeq, T}$ and SEL), but also the composition of the sonic environment and the way it is perceived by the users of the area. The design and functions of this App for the acoustic comfort evaluation is presented in the following paragraphs.
- External microphone with a windscreen: As the microphone of the smartphone has a high sensitivity to the wind, the kit includes an external microphone protected by a standard and verified windscreen. This solution also provides more accuracy.
- External equipment, connected via Bluetooth to the smartphone, measures the thermal conditions.

The accuracy of the noise levels measured by the kit was analyzed in terms of its frequency response and the differences in global noise levels (dBA), in comparison with a class 1 microphone. The purpose of the sensor is not reaching the accuracy of a sonometer class 1, but giving a global noise level with a difference of $\pm 2$ dB. The analysis considers the whole measurement chain: from microphone to acoustic app, since the comparison is made considering the final obtained results.

More information regarding the selection process of acoustic products and services and the calibration method used to check the accuracy of the acoustic sensors was presented in previous publications (9).

3. EXPERIENCE ASSESSING URBAN SPACES

During the CITI-SENSE project a practical experience was carried out to check the validity of the solution to invite citizens to assess urban spaces. 53 citizens were engaged in the initiative. All these volunteers were trained to use the designed kit. Each person participating in the data collection received the equipment: a smartphone with the external microphone and the climate sensor.

![Figure 1 - The CITI-SENSE kit](image-url)

Four public spaces were selected at the city of Vitoria-Gasteiz. The urban areas are diverse in order to test if the proposed methodology is sensitive to different acoustic comfort conditions. Each space was subdivided into two or three sites for its assessment, being a total of 9 sites:
Los Herrán square at the city center. It is a boulevard with some greenery but, as it is a key route of the city it has quite heavy traffic. It is divided into three sites.
- Constitución square at the city center. There are trees and a fountain on it and it is divided into two sites for doing the observations.
- Salinillas de Buradon park is located in the suburbs of the city. It is a new area not totally developed. There are two different sites.
- Olarizu is part of the green ring of the city, being a natural area well known by citizens. Two different sites are proposed.

![Urban spaces and location of their evaluation sites](image)

The following picture illustrates the protocol defined to make the acoustic observations. It describes the tasks that the user should make during the observation. It is considered that the entire observation takes about 20 minutes, measuring noise levels for at least 15 minutes.

**MAIN TASK**

**ARRIVING TO THE SITE FOR OBSERVATION**

**T:0 minutes**

Switch on the smartphone with the external microphone and the wind screen.

**T:1 minutes**

5 minutes of observation of environmental conditions at the site.

**T:6 minutes**

FILLING QUESTIONARIE

15 minutes of filling the percepción evaluation about the site.

**T:15 minutes**

END OBSERVATION

Stop the measurement and switch off the smartphone.

**T:20 minutes**

END EXPERIENCE

**Secondary task**

**ARRIVING TO THE SITE FOR OBSERVATION**

**T:0 minutes**

Check that the sound pressure levels are being measured and start doing the documentation about sound events.

**T:1 minutes**

Fill the information about sound events when it is asked by the smartphone.

**T:6 minutes**

Read the result of the ESEI (acoustic comfort) provided by the smartphone and the information of average LAeq and events.

Figure 3 - Protocol defined to make acoustic observations.
During the observation, the user interacts with the CITI-SENSE App and collects environmental data and gives his/her perception: how the place is experienced. In the following pictures the interaction between the user and the App is described, showing some displays that can be seen on the screen of the smartphone:

1-The main screen of the App of CITI-SENSE helps controlling the measurements and observations:

![Figure 4 - APP initial screen](image1)

2-The evolution of the values of the ongoing measurement is shown on the screen

![Figure 5 - APP screen to see evolution of variables](image2)

3 User is asked for fulfilling the questionnaire at the smartphone during the observation. The questionnaire comprises two parts: some general questions to be answered before any observations are made in the urban places and some questions to be answered in situ at the same time as the objective variables are measured: their global experience and perception of the place and the sound and thermal perception. In the case of acoustic comfort, soundscape in each site is evaluated using a semantic differential scale (10).

![Figure 6 - Questionnaire supported by the APP](image3)
4-A pop-up is displayed on the screen each time the CITI-SENSE App detects a sound event and the user is asked for providing information about his/her perception related to the event.

5- At the end of the measurement period the values that describe the acoustic comfort can be seen on the screen.

The assessment of the acoustic comfort is presented in terms of ESEI indicator values. A scale facilitates the participant’s understanding of the sound environment comfort level that the value represents.

Other variables are also displayed, such as $L_{Aeq}$, number of events and dominant sound sources. To obtain this information the App combines the physical results measured by the sensors with results of the citizens’ perception (obtained in the questionnaire).

Citizens that participated in the practical experience can access all the results once the observation finished. Tecnalia has analysed the data to make a quality control and to obtain conclusions about each public space, showing averages and deviations of data collected. All the results of the observations are uploaded and visualized on the web site of public space empowerment initiative in the CITI-SENSE project: http://vitoria.citi-sense.eu/en-gb/citisense.aspx. Users can view results of their personal observations and compare them with the average values of all the observations.

4. RESULTS OF THE EMPOWERMENT INITIATIVE ABOUT PUBLIC SPACES

The observations of the four places were made from 13 to 24 in April, 2015. 53 citizens from Vitoria-Gasteiz made a total of 137 observations, distributed among the four sites as follows:

- La Constitución square: 55 observations.
- Salinillas Park: 54 observations.
- Olarizu Park: 52 observations.
- Los Herran area: 76 observations.

Since there are few differences in the demographic characteristics of the groups that observed each place, it is considered that the sample of volunteers observing the spaces is valid to compare how the four spaces were perceived.

Figures 6 to 10 show some examples of the analysis of objective and subjective variables collected, regarding acoustic conditions at one urban place and its soundscape. Distribution of values collected in the urban area of Los Herran are presented: $L_{A_{eq,T}}$ values and number of positive and negative events. Results of the soundscape Semantic Differential assessment and identified dominant sound sources are also presented.
Figure 9 – Distribution of noise levels measured during the observations made at one urban space.

Figure 10 – Number of noise events identified by the system and assessed as negative by participants during the observation at one urban space.

Figure 11 – Number of noise events identified by the system and assessed as positive by participants during the observation at one urban space.

Figure 12 – Type of noise sources reported by participants as being dominant during the observation at one urban space.

Figure 13 – Mean result of the soundscape assessment (SD Scale) made by participants during the observation at one urban space.
The questionnaires also analyse the change on perceived health derived from staying at the urban spaces (comparison between emotions and stress reported before and after each observation). Results show that, in all cases, the level of stress was reduced from the initial situation and this reduction is more remarkable in spaces with more presence of natural elements and less noise. These results confirmed other studies that suggest that the characteristics of the urban places influence their restorative capacity from stress, highlighting the relevance of soundscape on this positive effect. (11)

The study of all the observations made in the city can also facilitate a better understanding of how citizens perceive the urban spaces. Each urban space has different challenges and opportunities and the strategies and actions to improve or preserve their quality can be defined according to citizens’ perception (12).

Figure 14 - Comparison of the average assessment of soundscape at the four spaces

Considering the results it can be said that the acoustic composition of the area has a direct influence on the perception of soundscape pleasantness. But the presence of greenery also contributes to the acoustic comfort in public places.

Going deeply in the different results obtained during the observations, we can conclude that the experience and the kit designed are useful to make decisions about interventions or actions to improve acoustic comfort in the different areas, since they not only give information but they facilitate considering real observations of the citizens.

The database built during the CITI-SENSE project offers a good opportunity to study the variables that influences the perception of acoustic comfort or soundscape, as each observation made by citizens at the urban spaces is described by 170 variables.

Therefore, data collected with the designed kit is being used to analyse the relationship of the calculated values of the Environmental Sound Experience Indicator (ESEI) at each place with other variables: soundscape perception, objective description of the place or acoustic parameters. As a preliminary result of this kind of analysis, table 1 shows a summary of the perception of soundscape in each area, an indicator about how many people would use the area for relaxing and the correspondent ESEI values.
Table 1: Results of acoustic comfort in each area

<table>
<thead>
<tr>
<th>Urban space</th>
<th>Soundscape perception</th>
<th>Objective description</th>
<th>People % that would use the area for relaxing</th>
<th>ESEI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Olarizu park</td>
<td>It is perceived as the best area in terms of pleasantness, natural and relaxing characteristics.</td>
<td>Natural area and well known by citizens.</td>
<td>95%</td>
<td>8.7</td>
</tr>
<tr>
<td>Salinillas Park</td>
<td>Its soundscape is perceived as pleasant.</td>
<td>There are not remarkable noise sources, nor vegetal elements.</td>
<td>70%</td>
<td>8.7</td>
</tr>
<tr>
<td>La Constitución square</td>
<td>It is perceived as familiar but less informative, without vibrancy and artificial.</td>
<td>The area is affected by traffic but has some greenery and one of the observation sites is protected from traffic noise, since is lower than surrounding streets.</td>
<td>60%</td>
<td>7</td>
</tr>
<tr>
<td>Los Herran</td>
<td>It is perceived as the worst area in terms of pleasantness. It is considered noisy, stressful, non-informative, chaotic and artificial.</td>
<td>Traffic is the dominant noise source.</td>
<td>22%</td>
<td>6.5</td>
</tr>
</tbody>
</table>

5. EVALUATION OF THE EXPERIENCE MADE BY CITIZENS

After the execution of the observation citizens who participated on the initiative were invited to a workshop, where they received feedback about results achieved in terms of the evaluations collected of each of the observed urban places. In this workshop an experimental exercise of empowerment was conducted: they were asked to identify the most value elements of the places and to give suggestions about how those places could be improved. Finally, attendees assessed the global experience and the solution to evaluate environmental quality at urban places. The results of the questionnaire filled in by the participants are shown in Figure 15.

![General evaluation of the experience](image-url)

**Figure 15** – Mean of the participant’s evaluation of the experience and solution scored from 0 to 5 (being 5, fully agree and 1 totally disagree).
Main conclusions of the workshop were the followings:
- Citizen’s opinion about the usability of the solution depends clearly on the commitment of the City with the obtained results.
- Some people valued positively the community created during the observations and the whole initiative and this community is considered positive in terms of empowerment to participate in decisions.

The technical solution (the kit) was also evaluated and their opinions depend strongly on the age of participants. While older people thought that the solution was complex and few intuitive, younger people consider it practical, user-friendly, manageable and intuitive.

6. CONCLUSIONS

The described solution is applicable for engaging citizens to evaluate in situ the acoustic environment and soundscape of urban places, integrating perception data with acoustic measurements made simultaneously.

The empowerment initiative developed in Vitoria –Gasteiz in the framework of the CITI-SENSE project was a pilot case with an experimental approach. The aim of the initiative was to check the validity of the solution and methodology to empower citizens on the decision making process related to urban spaces of the city, not being a real empowerment process itself. So, participants knew that the local authority was not committed to take the results of the study into consideration for their deployment.

Two main lessons were learnt to empower citizens on urban spaces’ environmental issues:
- A successful recruitment process requires that citizens have the certainty that their observations will be considered in the decision making process that affects the city.
- It is necessary to develop products to observe the city that are user-friendly and, at the same time, provide data accurate enough to evaluate the places.

This solution designed by Tecnalia can be applied for different empowerment initiatives on the management of noise and quietness at the city:
- Evaluation of quiet areas. It can be used as part of participatory processes to collect ideas for the improvement and preservation of those areas.
- Identification of priorities for Noise Action Plans, including citizens perception
- Participatory co-design of actions in the Noise Action Plan framework.

The concept of citizen observatories is expected to improve citizens’ participative processes on the urban design of their city. Tools developed in this framework will provide a complementary way to connect citizen and their local government creating a collaborative framework in specific decisions to improve, preserve or create public spaces.

ACKNOWLEDGEMENTS

This research was supported by the CITI-SENSE EU project.

We would like to thank our partners in the project, especially colleagues from Nilu, U-Hopper and Sintef, who participated in the development of the smartphone app. Special thanks go to our colleagues at Iritziak Batuz, who conducted the participant recruitment process for the demonstration exercise.

REFERENCES


7- Itziar Aspuru, Juan Angel Acero, Marta Gonzalez “Apps to encourage Citizen environmental participation in public space strategy and policy making”. Smart City Expo World Congress 2014 Barcelona,


12- Karmele Herranz-Pascual Laura Gutierrez Juan Angel Acero Igone García Alvaro Santander. Itziar Aspuru Environmental comfort as criteria for designing urban places. ARCHITECTURE, EDUCATION AND SOCIETY 4-6 JUNE 2014 BARCELONA