Mapping the sonic attributes: an acoustic approach for studying space

Bassiouka Afrodite[1], Karakosta Marianna[1], Lazoglou Miltiadis[1], Manika Stella[1], Papachristou Ioanna-Anna[1], Rista Eleni[1], Papadimitriou Kimon[1*]

[1] Department of Planning and Development Engineering, Polytechnic school Aristotle University of Thessaloniki , 59100 Veroia, Greece

[*] Corresponding author: email: *paki@topo.auth.gr*, Tel +302310996040

Abstract

Typical geographic analysis employs data that represent mainly the visual part of a given landscape in combination with spatially referenced data for selected attributes, depending on the aims of an application. Although sound is considered a dominant component of the environment it is commonly taken into account only as a quantitative attribute (e.g. noise mapping). Acoustic ecology studies the interaction between an environment and its habitants, through the sense of hearing. The term soundscape introduced to describe the sonic dimension of space.

This paper proposes a methodology for the representation of selected sonic attributes as cartographic layers. As an example, it is presented the mapping of soundscape around the installations of the department of planning and development engineering of Aristotle University of Thessaloniki.

Keywords: Acoustic Ecology, Soundscape, GIS, Visualization

1. INTRODUCTION

The effort of describing space is based on the registration of its attributes and their interpretation. While there are fixed ways to impress and interpret the visible characteristics this does not apply to the non-visible or subliminal qualities of space such as the influence or impact of sound. Typical geographic analysis employs data that represent mainly the visual part of a given landscape (e.g. relief and morphology) in combination with spatially referenced data for selected attributes, depending on the aims of an application. Additionally to landscape characteristics, “every place has its own distinctive sound picture supplementing our own personal history, our social history and that of the world in general with important information” (1). So the identity of a place is not only in terms of geography or physical- temporal aspects, but also by its acoustic properties. Sound acts as a messenger (2): as the sonic wave travels, it is charged by each interaction with the environment (3). Although sound is considered a dominant component of the environment it is commonly taken into account only as a quantitative attribute (e.g. noise mapping). Soundscape is a new alternative approach for studying landscape, which is based on perceptual and cognitive attributes (4, 5). Main components of soundscape are sound events which may be characterized as keynotes, sound marks and sound signals (6). This new approach recognizes that when humans enter to an acoustic environment, they have an immediate interaction with it (2). In other words it can be said that soundscape is the acoustic expression of landscape. This approach of studying space is one of the objectives of Acoustic Ecology (3, 7). From this perspective landscape should not be studied in isolated parts because every process that is performed in it can reform its ecological validity (8).The main belief of this theory is that landscape integrates representations of environmental sound classes with social and cultural references (9). Soundscape is shaped both by the inhabitants’ activities and their behaviour. Moreover, scientists believe that soundscape gives the inhabitants a “sense of place” and at the same time place’s acoustic characteristics are shaped by the inhabitants’

activities and behaviour (1). The quality of a place and its sounds is created exactly because of this interaction between soundscape and people.
The aim of this project is to provide a method for describing soundscape. Objectives of this study include capturing of qualitative sonic attributes, their cartographic representation and the definition of indexes that could describe the quality of an acoustic environment. The proposed methodology intends to reinforce our perception about space, in order to obtain an integrated approach on the study, planning and management (10) of areas with special interest.
.

2. METHODOLOGY

2.1 Defying the sonic attributes

According to (11) the acoustic spectrum can be classified in three main categories: anthropophony, biophony and geophony. The first category describes sounds that are produced by human activities (speach, machinery etc). The second relates to those produced by the rest of the vivid organisms (like birds, insects, animals, etc). And the third includes sounds that are generated by natural phenomena (e.g. wind, rain, waves) and spaces' morphology. By this way soundscape is described, apart from its quantitative attributes (sound pressure level measurements for noise mapping) by three additional qualitative attributes (anthropophony, biophony, geophony) which categorizes the sonic events according to their origin. Thus, every captured sound can be used to explain human and biological activities (geophysical sound are considered independent as they related to meteorological events and landscape morphology).

2.2 Study area

As an experimental place of study, was selected the campus of the Department of Urban Planning and Regional Development Engineering (Figure 1) a few kilometers from the city of Veroia, Greece. The landscape is composed by one – storey buildings, tall pine trees and grass cover, whilst neighbor landuse is mainly cultivated fields (Figure 2).

Figure 1. Views from the campus at the Department of Urban Planning and Regional Development Engineering (left: courses' buildings, right: administrative building)**.**

Figure 2. Overview of the study area (A: complementary building, B: courses' building, C: restaurant, D, E: administrative buildings, F: Egnatia road).

The daily presence of the students in the campus constitutes the main source of sound events around the university. In addition great deal of sound derives both from agricultural activities which are taking place around the south-east borders of the university as well as from Egnatia Road (major road that connects Eastern and Western Greece) which passes through the north-west borders of the area (Figure 2). Throughout the campus can be heard also many biological sounds (birds, small wild and domestic animals) which are hosted in the extended fauna. In Figure 2, red color indicates the structures that are related to anthropogenic sounds and with green color are marked the areas that hosts great deal of biological sound sources.

2.3 Capturing the unseen

Soundscape is an ever- changing expression of a landscape (12), so it is extended both in spatial and temporal scales (13). In order to capture its spatial variations the study area was covered by nine points, distributed all over the campus. Each point is considered as a sampling position to capture the acoustic information of the environment.

Three qualitative attributes (anthropophony, biophony, geophony) had been recorded simultaneously by nine students, for 5 subsequent minutes, using 15 seconds intervals. Each one had to estimate the intensity of anthropophony, biophony and geophony for every interval (15 seconds). The estimation for each sound category and for every interval was valued as follows: **1** for low intensity, **2** for medium intensity and **3** for high intensity (Table 1). The intensity of each sound category is calculated adding the recorded values during the five minutes period (sum A, sum B, sum G). By adding those three sums, is estimated the total intensity (I) for each sampling position.

Table 1. An example of the recording form for one sampling position (where A: anthropophony, B: biophony, G: geophony and I: estimation of total intensity).

Time (min)	1’				2’				3’				4’				5’				
(sec)	15	30	45	60	15	30	45	60	15	30	45	60	15	30	45	60	15	30	45	60	sum
A	1		1	1	1		1	1	1			1						1	1	1	11
B	1	1	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	21
G																					0
I																				sum	32

3. RESULTS

3.1 Mapping of sound categories

Using the resulting values for each sound category of all sampling positions, was performed a regularized spline interpolation (13, 14) in order to create represent cartographically the spatial variations of anthropophony, biophony, geophony. This resulted to three overlaying thematic maps that visualize the three basic components of the soundscape (Figure 3).

Figure 3. Mapping of the intensity of a) anthropophony (RED), b) biophopny (GREEN) and c) geophony (BLUE). White marks represent the position of the sampling points.

Color brightness is proportional to the intensity of anthropophony, biophony and geophony:

a) regions with bright red colour are those in which the human sounds are very intense. As the values of red are becoming darker, human sounds are decreased. The extension of bright red colours indicate plenty of human activities around the study area, b) luminous tones of green represent areas with intense biological sounds. The wide spread of light green colour indicates a non-urban character of the study area and c) similarly regions with blue colour are exposed to sounds that produced from natural phenomena (e.g. wind).

3.2 Visualization of the soundscape

Furthermore, the composite color map of the previous three layers (where Red = Anthropo, Green = Biological and Blue = Geophysical) is used for the visualization of the soundscape (Figure 4). Intermediate colours represent intermediate acoustic situations (e.g. yellow areas represent combination of human and biological sounds).

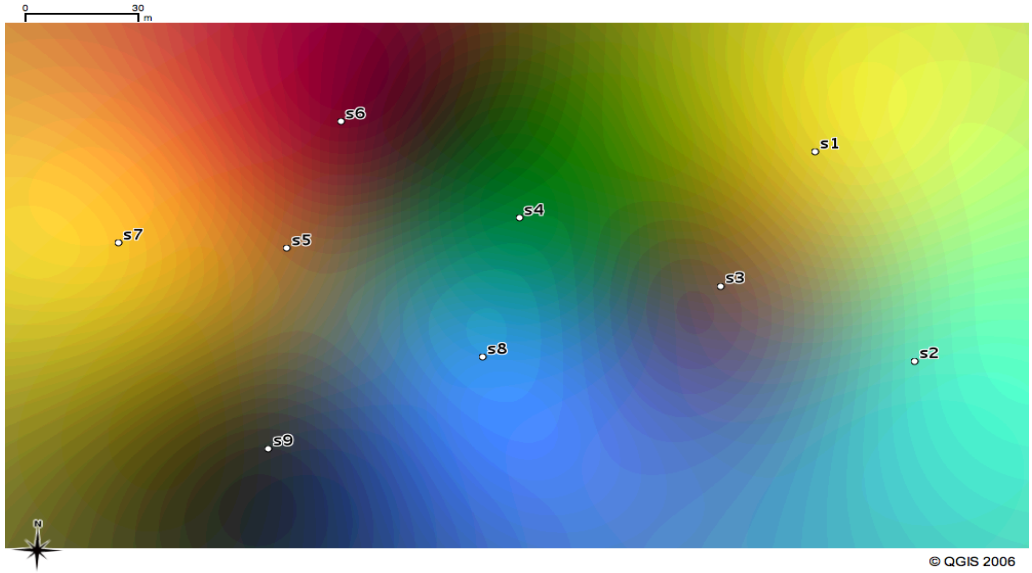

Figure 4. Soundscape is described by the composition of anthropophony (RED), biophony (GREEN) and geophony (BLUE).

3.2 Estimation of the intensity of soundscape

Interpolating the calculated sum (Equation 1) of the values for anthropophony (A), biophony (B) and geophony (G) it is produced a thematic map that represents the variations of the intensity of the soundscape over the study area (Figure 5).

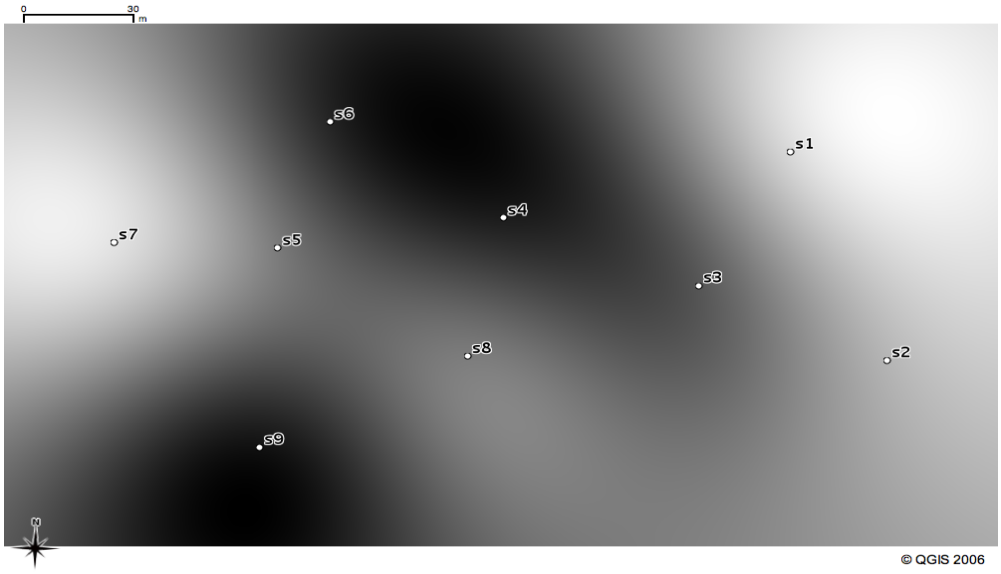

Figure 5. Estimation of sound intensity

Brighter grey (white) represents high intensity while darker tones (black) indicate low. Although this is only estimation and does not substitutes acoustic measurements (sound pressure level), it can be used to calculate the partial rates for anthropophony (Equation 2), biophony (Equation 3) and geophony (Equation 4) as indexes for comparisons between different soundscapes.

$$I = A + B + G \quad (1)$$
$$Ia = A / (A + B + G) \quad (2)$$
$$Ib = B / (A + B + G) \quad (3)$$
$$Ig = G / (A + B + G) \quad (4)$$

3.3 Index of equilibrium between human and biological sounds

The calculation of the ratio between anthropophony and biophony describes the equilibrium of human activities to the biological ones and it used to express the degree of human intervention in a given acoustic environment. The representation of its variation is calculated, performing map algebra (reference GRASS) dividing the anthropophony layer by the biophony layer (Figure 6).

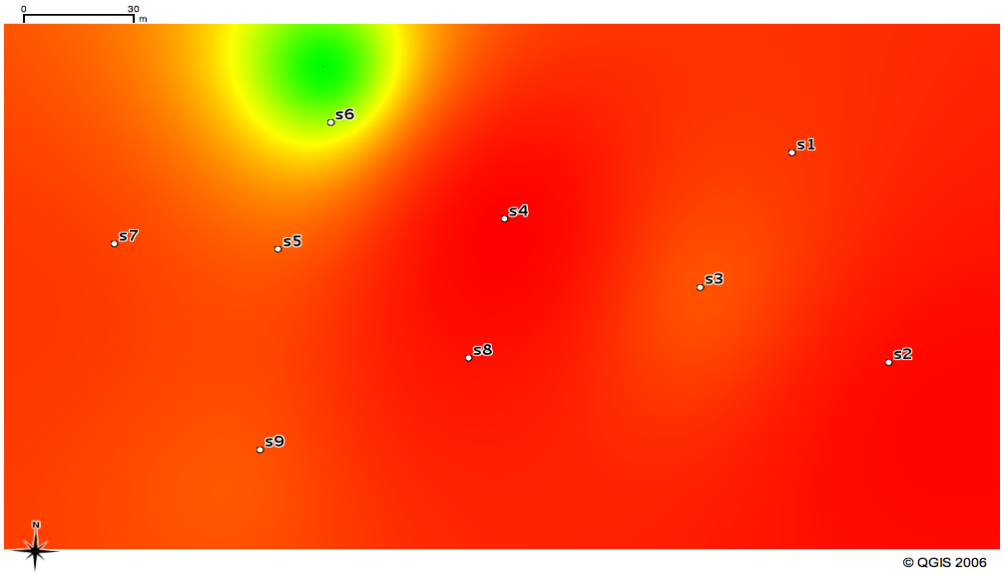

Figure 6. Index of equilibrium between anthropophony and biophony.

Higher values (above 1) indicate human dominance in the acoustic environment (red colour) and lower values (less than 1) describe areas which receive mostly biological sounds (green colour). Values around one (1) are used to define the limits between those situations (yellow colour).
It is clear that the study area is dominated by human induced sounds. This is obvious due to the activities taking place in the area (students walking and talking) and the surroundings (agriculture machinery, nearby highway). The biological sounds are limited in the north-western part of the study area where the buildings and the trees create a sonic “refugee” (Figure 3).

4. CONCLUSIONS

In this paper is proposed an alternative approach for studying space. Space is described via the mapping of the qualitative characteristics of soundscape that produces a certain location. The applied methodology produced several cartographic layers that describe the qualitative characteristics of soundscape. Three of them describe the origin and the intensity of the sonic events, a composite colour map recomposes the soundscape in a visual manner, one estimates the total sonic intensity and another represents the balance between human and biological sounds. The presented methodology allows an augmented description of a landscape, taking into account its acoustic dimension which emerges the human and biological activities through their sonic

expression. In this manner it is achieved the description of the acoustic environment and furthermore it can be used for its management through adequate planning and design (e.g. soundscape architecture).

ACKNOWLEDGMENTS

We would like to acknowledge the following students of the Department of Urban and Regional Planning and Development of Faculty of Engineering, Artistotle University of Thessaloniki, who participated in field observations: Athanasiadis Georgios, Alafostergios Charalampos, Avgerinos Kostas, Gargalis Leonidas, Karatakis Asterios, Stergiou Triantafillos, Tsavdaroglou Alexandros, Tsolakos Fotis.

References

(1) Velasco D., Island Landscape: Following in Humboldt's Footsteps through the Acoustic Spaces of the Tropics, LEONARDO MUSIC JOURNAL, Vol. 10, pp. 21–24, 2000
(2) Truax, B., 1984. Acoustic Communication. Ablex, New Jersey
(3) Wrightson K., 1999. An Introduction to Acoustic Ecology, Journal of Electroacoustic Music, Volume 12, March 1999
(4) Bregman A.S., 1990. Auditory Scene Analysis – the perceptual organization of sound. Massachusetts Institute of Technology. Cambridge
(5) Grano J.G., 1997 (1929). Pure Geography. John Hopkins University Press. Baltimore
(6) Truax, B., 1999. Handbook of Acoustic Ecology, 2nd Edition, (CD-ROM version), Cambridge, Street Publishing, Burnaby
(7) Damián Keller, Compositional Processes from an Ecological Perspective, LEONARDO MUSIC JOURNAL, Vol. 10, pp. 55–60, 2000
(8) Arkette S., 2004. Sounds Like City, Theory, Culture & Society 2004 (SAGE, London, Thousand Oaks and New Delhi), Volume 21(1): 159-168
(9) Schafer, R.M., 1994. The Soundscape. Our Sonic Environments and the Tuning of the World. Destiny Books, Rochester, Vermont
(10) Brown, A.L., Muhrar, A., 2004. An approach to the acoustic design of outdoor space. Journal of Environmental Planning And Management, 47, 827-842
(11) Cage S., Ummand P., Shortridge A., Qi J., Jella P.K., 2004. Using GIS to Develop a Network of Acoustic Environmental Sensors. Paper presented at ESRI International User Conference; 9–13 August 2004, San Diego, California
(12) Hedfors P., 2003. Site Soundscapes – landscape architecture in the light of sound. Doctor's dissertation. Issn 1401-6249, isbn 91-576-6425
(13) Kang M.A., Servigne S., 1999. Animated Cartography for Urban Soundscape Information, CM-GIS '99, Proceedings of the 7th International Symposium on Advances in Geographic Information Systems, November 2-6, Kansas City, USA
(14) GRASS Development Team, 2006. Geographic Resources Analysis Support System (GRASS) Software. ITC-irst, Trento, Italy. http://grass.itc.it