THE DETERMINATION OF THE URBAN ENVIRONMENT QUALITY IN ROMANIA'S CAPITAL BY SATELLITE IMAGE ANALYSIS

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ABSTRACT:

For Bucharest, the capital of Romania, a town with 2 million inhabitants and an area of 230 square kilometers, the problem of improving the ecological conditions is very actual and that is why it is a major strategic objective of General Urban Development Plan. For this reason, we think that it's very important for Bucharest to determine some areas based on environmental quality. We can successfully do this, by analyzing high resolution satellite images (IKONOS).

To determine the environmental quality in specific areas (districts and functional areas) we used together a series of qualitative and quantitative indexes which are proper to urban ecology and can be evaluated by computerized analysis of high resolution satellite images: buildings density (especially in residential districts), green areas surface per inhabitant, the risk of air pollution.

Taking into consideration the obtained data and the urban environment quality patterns, we could determine for Bucharest the following ecological areas categories: areas with very good ecological condition; areas with good ecological conditions; areas with middling ecological conditions and areas with precarious ecological conditions.

The map drawn after a detailed analysis of IKONOS satellite map, is very useful for urban remodeling projects, which mean to find the most proper locations to build the new residential districts and to improve the links between them and commercial and industrial districts, urban circulation network, entertainment areas.

1. INTRODUCTION

Environmental quality in the big cities represents a vital problem both for the individual as well as for the community. This is because the urban environment is strongly artificial and sometimes depreciated in comparison to the characteristics of the natural environment where the respective town developed.

For Bucharest, Romania's capital, a metropolis with two million inhabitants and a surface of 230 km^2, the amelioration of urban environment quality is extremely actual. We take into consideration the quality of the environment factors, which is sometimes precarious, and of the man-made elements as well as the extremely rapid and sometimes uncontrolled evolution of the urban area modeling and of the relation between the city and its suburbs during the last few years. Consequently this problem represents a major strategic objective of the General Urban Plan of Bucharest and its metropolitan area.

These considerations emphasize the importance of delimiting areas in Bucharest according to the quality of the environment for the projects of urban development. In this operation successful use can be made of the data obtained through the analyses of high resolution satellite images combined with live observations, measurements and cartography, with topographical plans and aerial photographs.

2. METHODOLOGY

In order to determine the quality of the environment in different urban areas, functional zones and administrative areas starting from high resolution satellite images we have put into operation a multicriterial analysis. This meant selecting and corroborating several criteria specific to urban ecology, estimating and summing up relevant qualitative and quantitative parameters through the computerized analysis of IKONOS images (1 m/ *pan*): the green areas reported to the number of inhabitants (square meters/ inhabitant), the concentration of constructed areas, the risk of atmospheric pollution. The representation at very large scales of the different components of the city of Bucharest made it possible to achieve detailed analyses and reliable estimations.
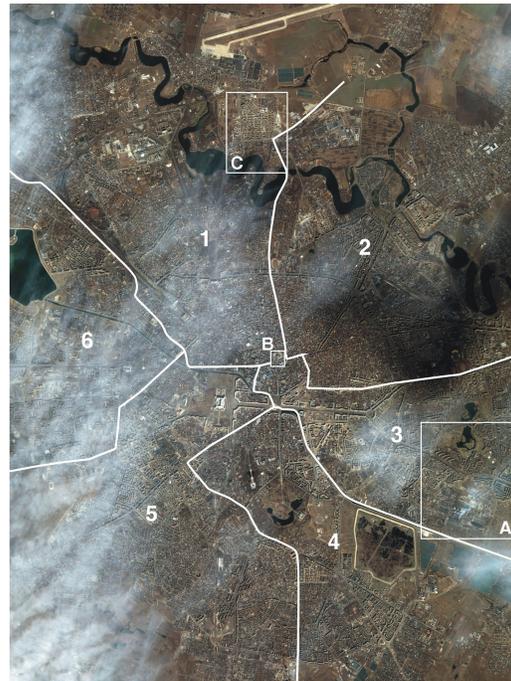
Figure 1. IKONOS image over Bucharest (2001).
The administrative limits of the 6 sectors are drawn.
Source: Space Imaging

The evaluation of these parameters has been made on representative areas from the three great structural-functional areas of the big city (central area, middle-intermediary area, peripheral area) where homogeneous areas were determined, in urban land cover, depending on the radiometric average values. By cumulating the data and reporting them to the existing environmental quality standards we established the categories of the environment quality and delimited, in a preliminary form, the areas corresponding to these categories. The drawing of area limits and the editing of the map were achieved using ArcInfo.

In order to apply the above method we focused on just one of the six sectors of the city of Bucharest – sector 1 – this sector presenting a great diversity of aspects (Figure 1). The map of environmental quality that we obtained in this way must be perfected by consulting topographical plans, aerial photographs and live observations, consequently becoming a reliable document in the project studies of urban remodeling. The satellite image and the thematic derived map shall be included in GIS, a modern instrument indispensable to improving the management of Bucharest's urban and metropolitan area.

3. CRITERIA AND PARAMETERS OF ESTIMATION OF BUCHAREST'S URBAN ENVIRONMENT QUALITY BY PROCESSING AND INTERPRETING HIGH RESOLUTION SATELLITE IMAGES

3.1. The quality of the natural elements

The quality of each natural element is essential in determining the sanitation of the urban environment. The analysis of high resolution satellite maps makes it possible to represent in broad lines the situation of air pollution and the condition of oxygenated areas (parks, squares, lakes, canals) with the possibility of calculating some important parameters concerning sanitation.

- identifying air-pollution sources and reporting them to the important constructed areas and green areas by correlating them with the direction and the characteristics of the winds (Figure 2).

Figure 2. A big residential district is under the influence of air pollution from an industrial zone

- determining and mapping the areas and lines of severe air-pollution (chemical, micro-biological, phonic). These correspond to the big central arteries and intersections with extremely agglomerated traffic, the traffic axis parallel to Dâmbovița canal, the boulevards that make up the inner circulation ring and especially the great intersections on the axis north-south (Pieței Libere Square, Victoriei Square, Charles de Gaulle Square, Romană Square, Universității Square, Unirii Square etc.).

From the analysis of IKONOS images we can approximate the degree of air pollution caused by the gases emitted by cars (CO, SO_2, NO_2 etc.) in a certain place (for instance, a big intersection in the central area) by calculating the traffic intensity: we make an inventory of the number of cars represented in the respective intersection by the satellite images, we give 15 seconds to each car for going through the intersection and we obtain the number of cars passing through the intersection during an hour through the place under consideration and knowing the composition of gases emitted by a car we can approximate their concentration for 1 hour, for 24 hours etc.

For instance on the basis of the satellite image in Universității Square we made an inventory of 103 cars. Given the calculation basis we have proposed it results that every minute 412 cars go through the intersection and in an hour 12360 traverse the crossroads (considering that 30 minutes per hour represent overall car stop time) (Figure 3). This situation refers to the most intense traffic period of the day, between 7.00 a.m. – 7.00 p.m. These cars produce in this square over 3 times the CO maximum admissible concentration.

Figure 3. A possible evaluation of the pollution degree based on traffic intensity in a determined place such as University Square (Piata Universitatii), viewed from a satellite image.

- the repartition of oxygenated areas (especially of green areas) and their relation to residential areas

The analysis of the IKONOS image allows us to calculate the parameters concerning green areas reported to the entire city, to sectors or to constructed areas: the weight of green areas, the surface of green areas per inhabitant. These data are reported to the standard values for an urban environment that would be optimal from an ecological point of view (25-4 m^2/ inhabitant: 25 m^2/ inhabitant = ideal; 4 m^2/ inhabitant = minimum admissible for the great metropolis ; WHO recommends 50 m^2/ inhabitant). These values lay at the basis of the definition and delimitation of the quality areas in the urban environment. The

analysis and the calculations indicate the fact that the most privileged area from an ecological point of view – an area with parks and lakes – is in the north, whereas the most underprivileged area is superposed on the densely constructed central area.

3.2. The quality of constructed areas

The quality of the urban environment is also given by the characteristics of man-made elements. Satellite images, even if they are of high resolution and large scale, do not allow the representation and evaluations but of some of these: the density of buildings, the road network.

Figure 4. The great density of the residential buildings (over 80%) from Pipera district which is situated in a most favorable ecologic conditions zone (northern part of the city) reduces the urban environment quality in this area.

- the density of buildings can be estimated (calculated) through the analysis of the satellite images taken by sensors of high resolutions. (Möller, 2003; Voorde Van de et al., 2004; Çetin & Musaoglu, 2004). The interpretation of the urban morphology and the spectral composition analysis of the elements that compose the urban tissue make it possible to determine the classes of density of constructed areas (on the basis of the radiometric environments of these homogeneous spaces) and to map the corresponding areas (Fahsi et al., 1996). Class 1 has a density of 0-35% (reduced density), class 2 has a medium density (35-65%) and class 3 has a density of 65-100 % (high density).

It is known that the density of buildings and implicitly the density of the population influence the quality of life in the urban environment. The denser the buildings and the more numerous the population the more the pressure on the environment is higher and the discomfort in the urban environment increases (Figure 4).

- the road network conditions the traffic on land (its fluency, intensity, distribution and structure) but also the degree of air pollution. On the IKONOS images we can clearly see the road network: the structures (from the general radial-concentric one of the entire city of Bucharest to the different structures specific

to the functional areas and to the areas of buildings), the connections between diverse structures that facilitate the flows in different directions inside and outside the city and also the critical points (discontinuities, variations of the transversal profile of the streets), the relations between the big traffic arteries and the zones of major public interest (the central area, residential areas, parks, cultural, commercial, sports centers). (Loghin, 2003)

4. THE DELIMITATION OF AREAS IN SECTOR 1, BUCHAREST, ON THE BASIS OF THE QUALITY CRITERIA AND PARAMETERS THAT CAN BE EVALUATED THROUGH THE ANALYSIS OF HIGH RESOLUTION SATELLITE IMAGES

By considering the criteria and by cumulating the parameters estimated through the analysis of IKONOS images it is possible to partially define the environmental quality criteria and to draw the limits between the areas that correspond to them. This opportunity has been demonstrated only for sector 1, Bucharest, an area characterized by a huge diversity of aspects. The urban environment qualitative criteria that were established are: very good (without industrial sources of pollution, with green areas of 35-40 m^2/ inhabitant, reduced density of buildings: 0-35%), good (with industrial sources of pollution having a reduced impact, air pollution caused by traffic, green areas of 15-20 m^2/ inhabitant, density of buildings: 35-65%), middling (intense air pollution caused by traffic, green areas 5-10 m^2/ inhabitant, density of buildings: 65-100%), precarious (very intense pollution generated by the traffic, green areas of less than 5 m^2/ inhabitant, associated or not with the density of buildings of 65-100%).(Figure 5).

Figure 5. Determination of the environment quality categories in the first sector of Bucharest city based on IKONOS image interpretation

Sector 1, Bucharest, covers the geographical and historical center of the city and the area towards the north of the city, on both sides of the major axis north-south. It comprises areas of the three main structural-functional zones: the central zone, whose main function are the services and which has the aspect of a modern metropolis; the intermediary zone, having mainly a residential function and keeping aspects of the traditional town; the peripheral zone, with multiple functions (residential, of recreation, industrial etc.).
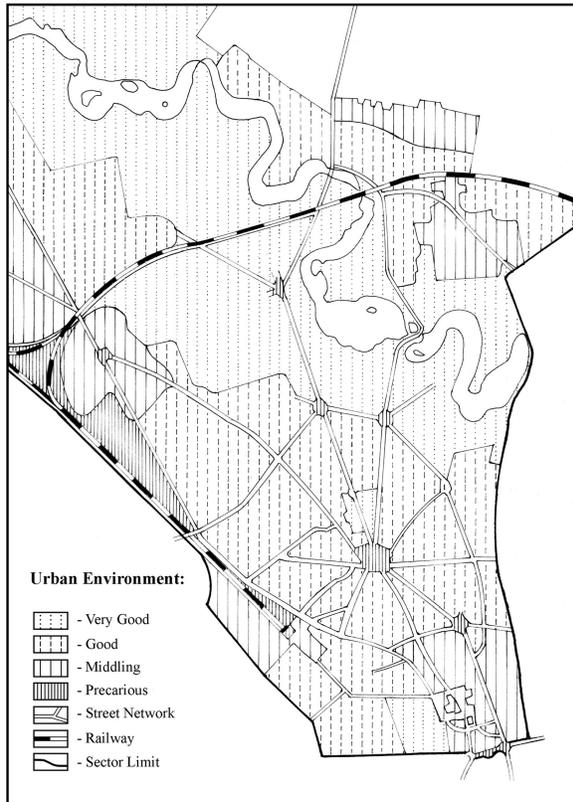

Figure 6. The urban environment quality from the first sector of Bucharest drawn after analyzing IKONOS image

On the IKONOS image we can notice these three main zones, differentiated from the point of view of the environment. Within them there are smaller areas having different degrees of ecological quality (Figure 6). This is how we have obtained the thematic map representing the territorial variation of urban environment quality in the sector under analysis.

5. CONCLUSIONS

Satellite images with spatial and spectral high resolution have a large potential for obtaining detailed geometric data and for realizing the land cover classification for the urban areas.
The analysis of the IKONOS image of the Bucharest (2001) through corroborating several ecological criteria and several parameters has allowed us to establish the environmental quality categories and to map the corresponding areas.
By visual interpretation we have realized:
1. the image classification aimed to determine the land cover classes based on the spectral properties of the urban components (buildings, green and water areas);

2. the mapping and measuring of the green surfaces, building density, of the pollution sources and affected areas;

Following those steps we have defined four urban quality classes and we have realized the thematic map of the sector 1 of the Bucharest, which was our field application.
The outcome results can represent an information source for updating the General Urban Development Plan of Bucharest.

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