CHANGES AFFECTING GREEN SPACE AND POPULATION. A MULTITEMPORAL ANALYSIS OF THE BUCHAREST CITY.

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ABSTRACT

Many factors affect the quality of life, one of them being the diminishing quality of the air. The fall in the green space area of the public use domain, such as the public parks, and the situation of the green belts of the Bucharest city, contribute to the issue of air quality quite significantly. There are specific regulations that provide for the areas of green space necessary for every person, but their spatial arrangement is not always uniformly distributed nor correlated with the population densities. Moreover, the green spaces contracted over the last decades due to the intensification of the built-up space. To address this, we used multitemporal analysis of remotely sensed imagery as a good possibility to assess the area of the vegetation at certain periods in time by determining the changes in the vegetation cover. This quantitative assessment of green spaces will probably be of influence in the introduction of future green space provisions related to the field of urban planning.

INTRODUCTION

In May 2013, the European Commission published a new strategy for encouraging the use of green infrastructure. The Communication “Green Infrastructure - Enhancing Europe’s Natural Capital” indicates that Green Infrastructure is a successfully tested tool for providing ecological, economic and social benefits through natural solutions, stating that it helps avoid relying on infrastructure that is expensive to build and which nature can often provide cheaper.

Green infrastructure is an interconnected network of green space that conserves ecosystem values and functions and provides associated benefits to society. The multiple uses and multiple benefits of green infrastructure are some of its major assets. Healthy, interconnected green spaces can provide mitigation of and adaptation to climate change. By planning and managing urban parks as parts of an interconnected green space system, cities can introduce flood control and storm water management of costs (1). Parks can also protect biological diversity and preserve essential ecological functions while serving as a place for recreation and civic engagement. They can even help shape urban form and reduce opposition to development, especially when planned in concert with other open spaces. Another value of interconnected urban green space systems is that they can enhance city aesthetics, help shape urban form, and improve urban quality of life (2). The Green Infrastructure is meant to offer a more flexible planning approach that “reconcile environmental concerns” with economic growth and social development (3). This concept sees the urban green spaces as multifunctional systems organised in natural, semi-natural and artificial networks, around and inside urban areas (4). According to the conclusions of (4) published as a result of a literature review the Green Infrastructure “can provide healthy environments and physical and psychological health benefits” to human beings. Therefore, as the health of humans is influenced by two major environmental factors: heat stress and air pollution (5), the urban climate should be taken into account and planning initiatives such as the Green Infrastructure policies should be based on scientific support and analysis.
According to (6), in Romania terms like green structure or green infrastructure are not sufficiently known or used. At the same time, the most well-known aspect related to green spaces is related to the so called “Green Cadastre” established through a series of legal provisions, between 2007 and 2010. According to the legislation mentioned before, all municipalities in Romania must comply to the requirement of providing public urban green space of minimum 26 sqm/inhabitant, before December 31, 2013.

One of the main objectives of the paper is to determine, using multitemporal analysis of remotely sensed imagery, if the distribution of green space areas in Bucharest is uniformly distributed and sufficiently interconnected in order to be considered as green infrastructure. Another important objective of this paper is to determine through the same multitemporal analysis the evolution and changes in Bucharest’s vegetation cover (both inside and outside the city’s boundary) over the last 25 years.

METHODS

Green belts were part of Romanian planning provisions since 2008 as they appear in the National Strategy for Sustainable Development which announces its objective that until the year of 2013 to design and implement plans for the development of green-yellow belts (wooded areas and farmlands) around the larger cities. Another objectives stated in this strategy assign the following targets: for the year 2020 to complete the development of green-yellow belts around the larger cities (rank I) and for the year 2030 to develop the green-yellow belts around medium-large cities(rank II). Regarding the city of Bucharest, they are also included in the new city’s strategy for the next 30 years. Recent changes in strategic thinking and zoning policies (7) regard the integration of the green belts with the concept of green infrastructure. The green belts concept has been “largely ineffective” (8) in managing the “protection and development of urban fringe areas” (9) as both greenbelts and agricultural zoning have contributed to the apparition of the leapfrog effect (10) when the new developments leap over the protected zones and spreads in the external space. Nevertheless, an increasing number of the policy makers, practitioners and academics have been drawn to the new concept of green infrastructure (3) (11), a concept presented in the introductory part of this paper.

In order to determine the evolution of green space cover areas in Bucharest over the last 25 years, we relied on the land cover classification for separation of greenspace. Landsat TM and OLI data were used to map the vegetation and forest landcover from 1989 to 2014. The main procedure was the image acquisition, calibration, classification and accuracy assessment. Due to the Resolution 2448/1952 released during the communist regime that was in power prior to 1989, the city of Bucharest was limited artificially in growth: both its perimeter and in its number of inhabitants. Hence his form was rather compact at the end of the 80’s. The initial image used for the multitemporal analysis was a 1989 Landsat image that corresponds to a fixed city boundary, making possible some estimations based on the statistical data available. The final image was chosen in order to fit the available statistical data. The comparative image was chosen in order to correspond to the same criteria of the availability of statistical data. Thus, even though in late years the city limits varied considerably, the 1 km² population grids uniformly distributed across the national level available since 2014 contributed in selecting the 2014 Landsat image for change detection. The classification was produced using a decision tree classifier, whose structure can be constructed by the use of expertise on the field or through rule-induction techniques due to observations (Lees & Ritman, 1991), thus the selected decision tree assumed that vegetation can be grouped into discrete groups of pixels. The structure of the decision-tree classifier was derived from using both observations and known information, as well as some of the conventional indexes and combination techniques: NDVI, NDWI, SAVI or NDBI. Image segmentation was used for further discrimination of features because it is suited when landscapes consist of patches as in the case of forests.
RESULTS

Different urban zones such as a city centre, a suburb, a park, an urban forest, a tree corridor, a lake or a river interact characteristically and distinctively with the urban atmosphere” (12). According to (12), changes in land-use do not directly cause shifts in climatic elements, but eventually set-up new climatic factors influencing particular areal types called “climatopes” ranging from several tenths to hundredths of meters. This areal types were introduced to differentiate between areas with similar microclimatic characteristics, such as: water body climatope, open land climatope, forest climatope, vegetation/green space climatope, town centre climatope etc (13). Some of this special areas were identified during the land use/land cover classification and can be used in further analysis: forests, vegetation, VHiBuiltUp (city centre) up to 10 different classes as they resulted in figure 1 for 1989 and figure 2 for 2014.

For the 1989 year, the city official boundary was 238 sq km, with a population of 2,067,545 inhabitants according to the Census data in 1992, with 34,712,237 sq m of green space representing 14.5% of the city’s area and a corresponding 16.78 sq m per inhabitant.

The evolution of green public space according to the official statistical records (14) is presented in Table 1 with the observation that from 2009 the values included the forests and parks covers, which were not included before 2009. The evolution for the entire city is presented in the figure 3. As it can be noticed, all the green space statistical data collected before the year of 2011 green cadastre, was only measuring the green public space, which not included all green space existing in a city, the remote sensing analysis of images being in this context one very good alternative of computing the vegetation cover. The changes affecting the vegetation cover as resulted from the Landsat imagery processing between 1989 and 2014, are shown in figure 4.

Table 1: Evolution and distribution of green public space in the six sectors of Bucharest in m²

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<tr>
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<tbody>
<tr>
<td>1</td>
<td>7,396,345</td>
<td>2,755,556</td>
<td>2,345,809</td>
<td>2,806,239</td>
<td>2,224,302</td>
<td>17,577,000</td>
</tr>
<tr>
<td>2</td>
<td>7,067,591</td>
<td>5,992,670</td>
<td>3,521,422</td>
<td>3,556,967</td>
<td>3,548,467</td>
<td>4,440,000</td>
</tr>
<tr>
<td>3</td>
<td>6,548,758</td>
<td>3,911,448</td>
<td>4,124,000</td>
<td>5,610,000</td>
<td>5,973,400</td>
<td>6,497,000</td>
</tr>
<tr>
<td>4</td>
<td>4,607,116</td>
<td>3,064,086</td>
<td>2,838,805</td>
<td>2,891,753</td>
<td>4,050,000</td>
<td>6,342,000</td>
</tr>
<tr>
<td>5</td>
<td>5,283,140</td>
<td>3,411,710</td>
<td>2,144,255</td>
<td>1,932,874</td>
<td>1,783,627</td>
<td>3,653,000</td>
</tr>
<tr>
<td>6</td>
<td>3,809,287</td>
<td>3,700,722</td>
<td>2,804,981</td>
<td>3,959,600</td>
<td>3,333,500</td>
<td>6,570,000</td>
</tr>
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For the year 2014, as resulted from the remote sensing analysis of the LULC classes obtained, the area of the green structure that intersects the relevant inhabited areas as resulted from the image processing is of 25369.2345 ha as shown in figure 5. The total population in the designated area numbers 2.259632 mil. inhabitants. This produces a rate of 112 sqm/inhabitant and if Romania must comply with the requirement of providing public urban green space of minimum 26 sqm/inhabitant, than that target could be met but only in the literal sense. In respect to the principle, the results show that in the city core, green space tends to very low values or in any case it’s lower than 26 sqm, as shown in figure 6.
The disturbances produced by each type of cover in the vegetation and forest areas are shown in figure 7 and 8.

CONCLUSIONS

The green space in the interior of the city has diminished and does not present any forms of continuity. The spatial resolution of the 2014 pan-sharpened image is 15 m and at least with this type of processing it does not catch small areas of vegetation such as tree alignments to the side of the roads. A good result is that the forest zones in a 20 km radius of the city seems rather constant, making a good possibility to use them in future flexible green belts planning. As a planning tool that can be employed is a support programme that motivates the land owners to willingly participate in a Green Belt Conservation strategy.

ACKNOWLEDGEMENTS

This study was carried out as part of the research project “Urban Climate Study of Bucharest/Romania” funded in the framework of the Romanian-Swiss Research Programme (RSRP 2011-2016)

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