EXPLORING THE CONTINUOUS BUILT-UP AREA – A METHODOLOGICAL EXERCISE. CASE STUDIES ON BUCAREST, IASI, CLUJ-NAPOCA AND TIMISOARA

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Abstract. This methodological exercise illustrates how the combination of classical statistical distributions can be used in order to explore the extension of the built-up areas in the nearness of some Romanian large cities. After the theoretical clarifications, we present the main results and the problems encountered when dealing with this particular kind of space.


Key words: continuous built-up area, density, distance-decay, rank-size distribution, grid

Cuvinte cheie: spațiu urban continuu construit, denstate, distanță, rang-talie, grid

INTRODUCTION

Enduring massive morphological changes in the transition and pre-adhesion period, the Romanian large cities seem to be involved in extension processes that are difficult to measure and understand. In this paper we furnish an incomplete spatial analysis frame of this extension spree, articulating the concept of density with the notion of build-up area with the spatial trends identified at local scales of observation. The issue of the continuous build-up area is quite new in the landscape of the geographical Romanian litterature. By rapid suburbanization and accelerated economic growth, the large cities are now, functionally and morphologically, overlapping the near administrative units (LAU2), introducing in the administrative and planning problematic the question of how to manage properly this new kind of space – the C.B.A (the continuous build-up area).
1. THE CBA IN ROMANIA – METHODOLOGICAL ISSUES

The apparition of the C.B.A. is independent in its manifestation from the administrative frame. Consequently, studying this aspect in a classical approach (using statistics extracted at LAU scales) is somehow inappropriate if one could want to understand the territorial mechanism of the urban growth. When the administrative limit is cutting a morphological constituted built-up area, this artificial discontinuity occults the forest and emphasizes the trees.

Secondly, it is imperative to understand that the C.B.A. is an important stake when used as criteria in the delimitation of what we might call over-administrative spatial units (FUA or Metropolitan Areas) with an eventual role in the financial irrigation of the territory. The example of the Romanian FUA is relevant in this aspect (the Functional Urban Areas were cut-off in a total disrespect of the word functional and they were generally reduced to their pure administrative frame).

Finally, the C.B.A. is an academic issue of the first importance when we take into account the heuristic dimension of the cumulated spatial processes registered at micro-scales of analysis. Our fear to approach this level of analysis is still a constant, the studies implemented at meso-scale being overrepresented.

Accepting the premise that the urban extension is not a chaotic phenomena (despite its appearances), but an ordered one, the order being a function of some geographical regularities, our objective reduces to the search of this potential order (foundational regularities). Generally, in geography we systematically intersect three types of “laws”. Their confirmation is ubiquitous and that’s why (sometimes) we regard them with some condescendence. The first refers to the rank-size distribution. By tradition, this distribution is used in order to measure the degree of order and disorder within a hierarchical urban system. Recent developments and new theoretical stands confirm us that the rank-size law is traceable even at lower levels of analysis. However, the exploration of this pattern is centered on the geographical model of population density repartition and not the C.B.A.

The second regularity that we constantly observe is linked with the role of distance in the manifestation of spatial processes. The distance-decay seems the most robust law able to explain the behavior of the territorial agents when captive to the principle of least effort (Goodall 1987, Groza 2005). In relation with the density issue, the distance decay was used to show the how this indicator decreases when the distance from the center of the agglomeration is growing (the so-called exponential Clark’s law, Clark 1951). Once again, the Clark’s law refers to the population density and not the CBA.

The third regularity is the Tobller’s law or the presence of the spatial auto-correlation in the studied phenomena. By spatial auto-correlation we generally accept that the attributes of the spatial units that we take into account trends to be more similar, the closest those units they are. As a matter of fact, the auto-correlation is nothing more than a derivative of the distance-decay observations. However, by tradition we could assimilate it to an independent regularity. Maybe the territorial auto-correlation (the effect of hierarchical appurtenance) deserves also the etiquette of law, but this aspect shall not be explored in this article.

Observing and exploring these three regular distributions in the same time, at low levels of spatial analysis, is not quite frequent. By empirical exploration of the spatial data we had the intuition that this triple coincidence is present when we focus on the issue of the
extension of the CBA in the nearness of the Romanian large cities. In a rigid nomothetic approach, we derived three working hypothesis in order to measure the subjacent spatial mechanism that underpin the urban extension bias the CBA.

The three sets of hypothesis introduce some methodological problems that we can resolve only by finding the proper compromise between our theoretical exigencies and the rapidity of calculus and analysis (and the last difficulty is not so simple to solve, expert opinion). Generally, the problem of the density was cartographically solved by using three methods: the choropleth maps, the isopleths ones and the random point illustration of the density. Because the population is always mobile in space, the three methods might be suspected of scientific artifact. However, the buildings or the roads or the parks are intuitively less mobile. The CBA is fixed and not dynamic. This difference also introduces a methodological issue. The differential problem occurring when coping with the densities simply derives from the spatial mobility of the indicator. In this logic, finding the best method able to indicate the trends in the manifestation of the spatial extension of the CBA becomes a crucial one.

Defining the CBA is another technical problem that we must overcome, if we want to confirm or infirm our working hypothesis. The delimitation of the continuous built-up area is a matter of empirical investigation and some routine drawing, especially when vectorising all the buildings present in Romania. After the comparison of the different sources, we were methodologically and technically forced to reduce our field of investigation to the results offered by CLC 2000. In order to benefit of a larger mass of CBA information, we intersected the CLC 2000 with a grid information system having a cell of 500 m. We collected the area information regarding the CBA and we have systematized the information in order to solve our working hypothesis. As a testing methodological approach, seeing that the relevance of CLC 2000 is somehow reduced (based on the photo-interpretation of satellite images and meanwhile knowing that some categories are not relevant for Romania), we also take into account the role of the road density. Using the 1 : 50 000 topographic

<table>
<thead>
<tr>
<th>Regularities</th>
<th>Hypothesis</th>
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<tbody>
<tr>
<td><strong>Rank-Size</strong></td>
<td>H0 : We observe a rank-size distribution of the CBA in the proximity of large Romanian cities.</td>
</tr>
<tr>
<td></td>
<td>H1 : negation of H0</td>
</tr>
<tr>
<td></td>
<td>H2 : we are not able to confirm neither infirm this distribution.</td>
</tr>
<tr>
<td><strong>Distance decay</strong></td>
<td>H0 : The density of the CBA is subject to the distance-decay law.</td>
</tr>
<tr>
<td></td>
<td>H1 : negation of H0</td>
</tr>
<tr>
<td></td>
<td>H2 : we are not able to confirm neither infirm this hypothesis.</td>
</tr>
<tr>
<td><strong>Auto-correlation</strong></td>
<td>H0 : The residuals of the prior HO are spatially auto-correlated (positively or negatively).</td>
</tr>
<tr>
<td></td>
<td>H1 : negation of H0</td>
</tr>
<tr>
<td></td>
<td>H2 : we are not able to confirm neither infirm this hypothesis.</td>
</tr>
</tbody>
</table>

Tab. 1 Articulation of the spatial distributions and the working hypothesis
Articularea ipotezelor de lucru cu tipurile de distribuție spațială

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maps, we have extracted the road network and, in the case of L-34-104 map sheet (Caras-Severin) we have calculated the road density.

![Road density in L-34-104 map sheet (Caras-Severin)](image)

The image suggests that the CBA could be correlated with the road network and this visual correlation might function as delimitation for a potential morphological agglomeration independent (again) of the administrative limits.

### 2. CONFIRMATION OF THE HYPOTHESES

Primarily, the issue of the rank-size distribution in the reparation of the density of CBA in the vicinity of the large cities is confirmed, but this confirmation is relatively distanced from the classical form of the distribution. By a rank-size distribution applied to the urban systems, we usually understand a rank-decay of the indicator approximated by power functions. In our case, the density of the CBA intersected by the grid shows that the rank-size distribution also exists, but in a linear form of manifestation.
The results were not confirmed only for Iasi, but also for Bucarest, Timisoara and Cluj, with different slopes and intercepts. If the distribution of the density of built-up space is subject to the rank-size distribution, we might suspect the existence of a structuring mechanism behind this statistical evidence. However, being an a-spatial distribution, the questions regarding its interpretation still remain, like in the cases already described by the urban systems regularities. The presence of a large amount of negative residuals suggests that the build-up potential is under-exploited in the case of Iasi, compared with Bucarest. The correlation and the slope at Bucarest are significantly larger than the indicators for the oblivion/forgotten capital of Moldavia. This analysis could also function as a test for the CBA lacunarity in the proximity of the large Romanian cities or as an alternative to already classical fractal-based approaches (Groza, 1996; Frankhauser 1998). The results obtained in the case of Iasi and Bucarest partially overlay the exploration of the rank-size distribution of densities described by J.Li, D. Wong and D.A. Griffith (Annals of GIS, 2009), excepting the fact that the cited authors are using a logarithmic approach of the rank and completely different definitions of the density concept. All in all, using the gridded values of the CBA the H0 hypothesis regarding the rank-size regularity seems to be confirmed, at least for the case of Romanian large cities, such as Bucarest, Iasi, Timisoara and Cluj. In addition to this basic analysis, we should complete this first dimension of our theoretical and empirical confirmation by random tests, in order to show that the rank-size distribution is not induced by hazard/random.

Secondly, the distance-decay regularity in the distribution of the CBA in relation with the centers of the agglomeration was also confirmed by the statistical analysis. When the correlation between distance and the cumulated density of the CBA is present, the shape of the mathematical function varies from city to city, as shown by basic indicators such as the R2. Again, in the case of Iasi and Bucarest the differences are linked with the elated CBA and its repartition is subject to local discontinuities induced either by natural factors, or by unequal trends of recent suburbanization.
This R2 function could also be used as a tool for the delimitation of the morphological and functional agglomerations when combined with the previous results. What intrigues is the body of the functions taken into account. If Bucarest presents a negative gaussian exponential allure (with a radius of approximately 15 km.), the case of Iasi is amorphous.
and difficult to include in simple mathematical shapes. The discrepancy between the two graphics might indicate the immediate potential influence of the two cities in a range of 30 km and the associated trends of the CBA extension.

If the first two hypotheses were confirmed, the issue of the spatial autocorrelation remains opened. Usually, using the Moran’s I or the Geary spatial auto-correlation indicator represents the classical approach of this problematic. We preferred to implement an alternative method developed by C. Grasland (2003), a method that include two different dissimilarity variables, in function of their declination in a range of 2 km. in the vicinity of every baricenter included in our study. For Iasi and Bucarest, the calculated auto-correlation of the negative residuals produced by the rank-size distributions were insignificant (-0.05 for Bucarest and -0.02 for Iasi). The absence of the auto-correlation can be explained by the repartition of the measure points (the gridding system of 500 m) and by the phenomena per se. As a preliminary conclusion, dealing with the extension of the CBA might be simplified by using classical techniques (rank-size or distance-decay), however, the analysis of the residuals (perceived as the manifestation of chaotic spatial local scale processes) illustrate the methodological difficulties when approaching the issues of the built-up areas.

Three hypotheses and only two confirmations. It seems that the issues induced by the problematic of the continuous built-up area are too complex to be framed by largely (but statically) observed mechanisms. One of the problems linked with the set of three chosen working hypotheses is their lack of dynamism in the graphical representation (a sine qua non step in the eventually analysis of the CBA). Complementarily, we chose to analyse the spatial repartition of the CBA using a trans-scalar representation method – the moving window and the interpolation of the resulted values. The radius used to apply this method is varying from 1 to 2 and than to 4 km. The mapping of the results shows an ambiguous report between the lacunarity of the CBA and the role of the radial privileged transportation axis. The spatial patterns produced by the cartographic exercise oppose two ancient capitals (Bucarest and Iasi) and two large cities with metropolitan potential (Cluj and Timisoara). Is the opposition between the two categories of cities depending of an historical path dependency?
Fig. 4 Mapping the CBA densities with different moving windows
a. Moving window – radius 1 km. b. Moving window – radius 2 km. c. Moving window – radius 4 km. d. Trans-scalar density analysis for Iasi (the density of buildings)

Cartografierea densității spațiului urban continuu construit
Combining the clarifications produced by the rank-size distributions, by the distance-decay regularity and by the graphical representation of the CBA density, could furnish us a multi-criteria analysis able to better delimitate the morphological and, implicitly, the functional urban areas present in Romanian territory. Articulating these three methodological approaches and taking into account the different patterns exhibited by the large Romanian cities involves a set of specific operations (derived from the GIS spatial analysis techniques). As shown by the study experience on the Caras-Severin map sheets, when working with other networks of settlements (rural spaces), the delimitation of the CBA should be completed with the road’s network analysis. The synthesis of the work produced is shown in the table below:

<table>
<thead>
<tr>
<th>Steps</th>
<th>Methods</th>
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<tbody>
<tr>
<td>Extraction of CLC 2000</td>
<td>Extraction of the built-up area</td>
</tr>
<tr>
<td>Extraction of the built-up area for the main cities</td>
<td>Intersection with a fine grid (500m)</td>
</tr>
<tr>
<td>Intersection with a fine grid (500m)</td>
<td>Rank-size distribution confirmed</td>
</tr>
<tr>
<td>Intersection with a fine grid (500m)</td>
<td>Distance-decay presence confirmed</td>
</tr>
<tr>
<td>Extraction of residual values (rank-size)</td>
<td>Calculus of the spatial auto-correlation</td>
</tr>
<tr>
<td>Lack of spatial auto-correlation undermines the problematic</td>
<td>Commuting on the graphical representation problems</td>
</tr>
<tr>
<td>Calculating the densities in a moving window (1,2,4 km)</td>
<td>Mapping the results</td>
</tr>
<tr>
<td>Intersecting the results with special problems induced by the type of space taken into account</td>
<td>Visual comparison</td>
</tr>
</tbody>
</table>

**CONCLUSIONS**

This article shows that the exploration of the extension of CBA (continuous built-up area) can be much more productive when we combine statistical analysis (rank-size, distance-decay distribution, spatial auto-correlation indicators) with graphical illustration of density (based on a grid system). This combination of analytic tools becomes one methodological way in order to delimitate the morphological urban agglomerations in the proximity of some Romanian main cities. The text of the article should be read and interpreted as a perfectible exercise that ignored the official LAU2 statistics. The results are likely to be criticized but they can also furnish primary spatial data for the local stakeholders involved in the planning issues at micro-scale.
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