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BUILT-UP AREA CHANGE ANALYSIS IN IASI CITY USING GIS

Ursu Adrian¹, Andrei Marius¹, Chelaru Dan Adrian¹,
Ichim Pavel¹

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Abstract. The study analyses the spatial and temporal changes occurred in the built-up area of Iași city and its surrounding areas using cartographic materials from different time periods. The paper aims to highlight the areas where the most significant changes took place by identifying the main evolution patterns, generated by certain natural or human-driven factors. The results of the study were achieved by using specific photo-interpretation methods of the available orthophotomaps from 2006 and 2012, mainly using the professional GIS softwares TNT Mips 7.2., ArcGIS 10.2 and Global Mapper 11. The changes have led on the one hand to the conversion of the former industrial areas and thus, the urban regeneration, but also to the periurbanization phenomenon, with major functional and structural effects.

Introduction

Urbanization is arguably the most dramatic form of irreversible land transformation (Taubenböck et al., 2009). Urban growth prediction is often based on the dynamic land use/cover pattern and its relationship with selected socio-economic factors. Land use change in metropolitan areas typically reflects economic development and population growth. Thus, the analysis of spatial-temporal patterns for land use/cover provides an objective basis for understanding the relationships between urban growth and related economic, population and environmental factors (Irwin & Geoghegan, 2001, cited by Liu et Zou, 2005).

The consequences of the anthropogenic pressure over the territory are related to the lack of space, especially through built-up area expansion at the expense of agricultural land and changes in spatial mobility of population. This kind of pressure affects the quality of life in a negative way, through pollution, congestion, and positively, through accessibility to modernity and increasing the comfort level (Chelaru et al., 2013).

¹ „Alexandru Ioan Cuza” University, Iași, Romania; ursu_v_adrian@yahoo.com

To address these pressing issues requires a complex analysis of the built-up urban space and its evolution. The digital images offer an unprecedented opportunity to develop precise comparative indicators. By using these data in a coherent comparative analysis, the article aims to strengthen the understanding of the main factors that contribute to the urban development of the city and its peripheral areas.

The city of Iasi was developed historically as a result of its strategic location, being located on a hilly region that assigns the city a particular urban personality. Nowadays, the city represents a regional metropolis, which is situated in North-Eastern part of Romania, in the historical Moldavia Region, being the most important urban center from the region, with a population of 350.000 inhabitants, according to the 2011 census.

1. Data and methods

The main methods used for the spatial analysis are remote sensing and photo-interpretation. Firstly, one has drawn a rough limit of built-up areas of Iasi city and its surrounding areas in Google Earth. The limit was necessary in order to export the aerial images from Google Earth at high resolution. All raster files were georeferenced by the correspondence method, so that these raster files to be brought in the same reference system. These processes suite were needed only for the aerial images from 2009 and 2012, for 2006 being available the orthophotomaps from ANCPI.

Once the database was created, we could start the process of digitizing the buildings on the 2012 orthophotomaps. Then, the resulted layer of buildings was superimposed over the 2009 and 2006 images, in order to achieve more accurate comparison. For the peripheral areas, this method was applied only for the 2006 images.

2. Results

The city of Iasi experienced significant changes in the analyzed period, both in terms of built-up area expansion, but also in terms of modifying the urban space configuration.

Both urban expansion and urban sprawl are forms of cities' growth, but they should not be confused with it: urban growth can be achieved without necessarily increasing the urban territory, by re-densification (infill development) of existing urban fabric, peripheries renewal, or reconstruction of the city onto itself. Furthermore, urban growth is a result of the natural urban dynamic – a phenomenon that strongly binds on the demographic mobility and economic developments in the regional context (Stan A., 2013).

Following the laboratory analysis, based on existing cartographic materials, and also the field study, we identified certain evolutionary patterns that changed the functionality of the specific areas under consideration. The most important changes identified at local level are related to the conversion of former industrial areas into commercial, real estate areas, or the densification of these urban areas.

2.1. Urban space dynamics

One of the most important phenomenon identified at urban scale is the continuous change and diversification of the districts functionality, as a result of a complexity of factors such as demography or the local economy.

Given the disappearance of the initial functions of most industrial sites, resulted after the local or national policies of urban restructuring, the functional conversion of these sites was inevitable. Former industrial units have large areas of land situated in key locations for the city development.

Nowadays, the industrial activity of Iasi city has declined considerably, reaching to a nearly non-existent stage at present. Some of the spaces left by deindustrialization were leased to small businesses for production activities or storage, while some areas remained completely unused.

The configuration of the old industrial buildings shows a chaotic internal structure, being the result of unsystematic development, with reduced functionality. Also, it should not be neglected the contamination level of the sites resulted from industrial activities that took place here.

The analysis revealed certain evolutionary patterns of urban space configuration of Iasi city:

✓ ***Brown field investment - conversion of the old industrial sites into commercial areas.*** Brown field investment type is when a company leases or purchases existing production facilities to launch a new production activity (ex: Nicolina district). The overall dynamics of this area can be described by passing from units with warehouses to an area with commercial centers. According to the local authorities, the further development of the area will consist in a real estate mega project.

The changes occurring the Nicolina district took place starting with 2007, when it began gradually to disappear the old industrial sites such as IASITEX or Tesatura Clothing Factory (fig. 1 - a.). The new commercial units appeared on these sites were supermarkets such as Kaufland (2007) or Mr. Bricolage (2010). Also, according to the local authorities, the project of restructuring the old factory aims to create a new Mall, called Green Plaza, an area of 4,6 hectares of commercial and office spaces.

Another example is the industrial site affected by the conversion process, located between Bularga district, Chimiei Boulevard and Tudor Vladimirescu Boulevard (fig. 1 – b.). The first changes occurred also in 2007, when there were created the first multinational companies: Carrefour and Practiker. In 2009 there was opened a new bricolage store – Baumax, and in 2012 were founded the Imperial Hotel, Lidl and Kaufland supermarkets, or an appliance store.



Fig. 3 – a. The evolution of built-up area in Nicolina district (IASITEX old factory and Nicolina) during 2006 to 2012; b. The evolution of built-up area of ZIMBRU factory and TEROM S.A. during 2006 to 2012

✓ **Green field investment** – form of foreign direct investment where the parent company starts a new business in a foreign country by constructing new operational facilities from the ground up. Thus, deindustrialization of the economy led to smaller fluxes towards the former industrial areas and an increase in fluxes towards the new commercial-industrial areas spawning west of the city (Ursu et al., 2015). If traditionally most of the productive investments were made in the South-Eastern part of the city (downstream), in recent years the investments are made mostly in Western part of the city (upstream), where can be found areas suitable for

developing new industrial sites. This area is preferred by the investors due to low prices and high accessibility to main communication routes. This area attracted investors from various fields of activity, from automotive industry (Delphi – fig. 2), to commercial units (Carrefour ERA – fig. 3, Decathlon, Praktiker, Metro etc.), car dealerships or different office buildings.



Fig. 4 – Delphi Diesel Systems in Iasi – 2013
(source: ziaruldeiasi.ro)



Fig. 5 – Carrefour ERA Iasi - 2014
(source: era-iasi.ro)

✓ There are also a number of **former industrial areas that have been decommissioned and/or demolished, which did not benefit by further investments**. A particular case is the former industrial buildings, which, although are found in an advanced degradation state, can not be demolished or be made additional changes because of their registration to the **historical monuments** list at local/regional/national level. This category includes the Cigarettes factory from Iasi, which was established in 1864. It is the oldest cigarette factory in the country, being declared a historic monument, although at the present it is in ruins.

✓ **The conversion of the old industrial sites into residential areas** (ex: Copou area). Being a highly profitable residential area, the old industrial sites of Copou district have been transformed into high-quality real estate areas. The best example is the residential complex “Exclusive Residence”, whose construction begins in 2011, finishing the first 3 buildings in 2012. This real estate complex was developed on the old site of “Textila” Factory Iasi, which was almost totally demolished (fig. 4 – c.).

✓ **The growth of the urban space density**. The most important densification of urban space occurs in the center of Iasi municipality, over the old municipal swimming pool, where it was built the Palas project, a whole urban complex that includes shopping malls, office buildings, hotels, parking and a park with over 50.000 square meters of green spaces. This project introduced the concept of “lifestyle center” in Iasi city. The facility covers a total built area of 270.000 square meters and required an investment of 265 milion Euros (fig. 4 –d.).



Fig. 6 – c. The evolution of built-up area in Copou district (the old site of Textila factory) during 2006 to 2012, d. The evolution of built-up area in the center of Iasi city (Palas project) during 2006 to 2012

2.2. Territorial expansion. Periurbanization. In addition to the internal changes of the built-up space, the city of Iasi, being an attractive growth pole for the region, has experienced during recent years a number of significant changes. These changes were dictated by several factors such as accessibility, the price of the terrain, the proximity to certain services, or the quality of the natural and human environment.

The most important trend shaped in the spatial evolution of Iasi city is the **periurbanization** process. The city's limits expand rapidly along the communication axes, as a consequence of focusing complex and selective demographical tides. These are at the basis of new districts well individualized by the socio – professional structure, the architecture and the urban aspects: luxurious villa districts, situated along the principal roads, on high quality terrains such as Miroslava, Valea Adanca, Iezareni, Paun, Pietraria, or Valea Lupului. The low outcomes population goes to the semirural marginal districts, lacking urban utilities and situated on unfavorable terrains (Manta Rosie, Pacuret etc.). The urban limits'

growth is also based on the proliferation of the commercial units at the city's outskirts, along the communication axes: oil stations, commercial storehouses, auto showroom etc. (Stoleriu O. & Stoleriu C., 2004).

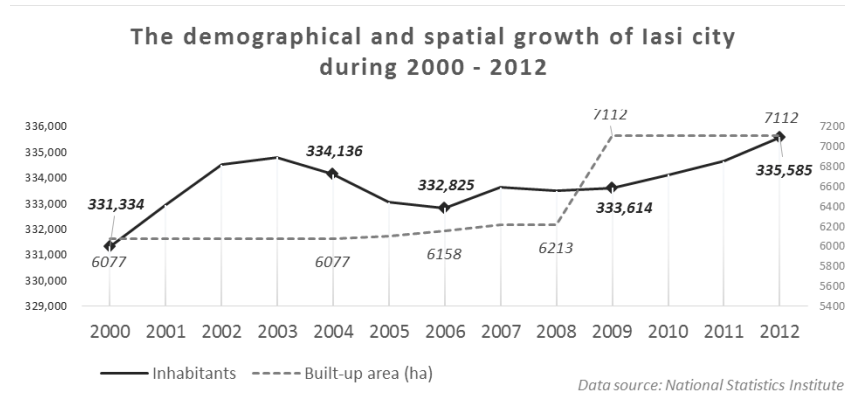


Fig. 7 – The demographical and spatial growth of Iasi city during 2000 to 2012

According to National Statistics Institute, the period after 2006 reflects a significant increase of inhabitants, which led to a significant increase of built-up areas (fig. 5). Comparing to 2006, the number of inhabitants of Iasi city has increased by 0,83%, while the built-up area increased by 15,49%. This can be explained by a spontaneous expanding and densification of the urban outskirts, which attract high-income population, but also poor people returning to a semi-rural way of life. Regarding the urban population density, its value decreased by 12,70 %, from 54,05 inhab./ha in 2006, to 47,19 inhab./ha in 2012.

Driving forces and morphomechanisms of the territorial expansion. The analysis of the cartographic documents from different time periods reveals a number of evolutionary patterns of the peripheral area of Iasi city. The morphological and spatial patterns are explained in connection to morphological mechanisms occurring in sprawl areas, due to different driving forces (Stan, 2013).

The analysis shows that the built-up area expansion was made firstly due to favorable areas in terms of accessibility, price, or natural factors, and also to the proximity of recreational areas. In short, for the first analyzed period, one can notice a tentacular expansion of the built-up areas, along the main communication axes of the city. These areas then suffered a rapid densification of built-up space, as a result of the economic growth, with an increased pressure on the less favorable areas in terms of housing needs.

The relation between the city and the natural environment plays an essential role. The emergence and the development of cities took firstly into account the

geomorphological status, but also geological, hydrogeological and climate factors. The local environmental conditions were considered in selecting the location, so that it can safeguard the city against floods, drinking water and favorable land for building. Nowadays, the choice of the location is sometimes imposed by positional advantages, so that the humans had to adapt to more restrictive conditions and profoundly change some specific environmental components (Ungureanu Al., 1980).

The suburbanization process is also being influenced by the migration of the urban population towards the neighboring villages with the aim of assuring a better quality of life. It can be considered a reversal of conditions: the replacement of the rural exodus (as a result of closing of factories and lack of employment) with a new rural phase, of individuals with above average financial status moving towards the periphery of the city. After 1990 the lack of legislative discipline led to chaotic development and spread of built space (Ursu et al., 2015). The territorial expansion was made due to the population's desire to increase their comfort level, in particular by villas building type, requiring larger space. In certain areas, there is still some peripheral land that meet the current comfort indicators for private houses, that has a good accessibility to the main attractions of social, economic or otherwise.

Based on documentation activities, but also on the cartographic analysis and field studies, one can identify several **evolutionary patterns** of the built-up space in peripheral areas of Iasi city (fig. 9):

At first, **the high degree of accessibility**, characterized by the proximity to the main communication axes of Iasi city, acts as main factors in selecting the areas suitable for constructions. Thus, especially for the first period under observation (2004 – 2006), the territorial expansion of the peripheral Iasi area was made along the roads, as it can be seen on the maps (fig. 8). The most suggestive examples include Valea Lupului – DJ 280E, Miroslava – DJ 248A, Rediu/Breazu – DJ 282, Aroneanu – DJ 282G, Bucium – DN 24, or Lunca Cetatuii, where the new modern belt road increased exponentially the number of dwellings in the area.

Also, an important role for the territorial expansion of built-up area is played by the **natural factors**, which have favored supplementing the unoccupied spaces. In the first period under observation, the newest built-up spaces were made mainly in areas favorable in terms of declivity or slope orientation. The analysis shows some built-up spaces on areas less favorable, which are found in isolated areas.

In order to achieve a more detailed analysis of this phenomenon in Iasi city, by using the GIS environment we analyzed the natural conditioning factors for the territorial expansion and their favorability for construction.

Referring to the **declivity** factor, the built-up area distribution over the resulted slope classes highlight certain areas which are most favorable for construction. Thus, the areas with the highest favorability are represented by the low areas, with slopes less than 3° (fig. 6). There can be also found small areas with high favorability, but certain factors such as the distance, the undeveloped roads, or even some natural obstacles make these areas difficult to be valorized. Between 2006 – 2012 there is an increased rate of constructions on the less favorable classes (5-10°, 10-15°, even above 15°), indicating the high anthropic pressure and the growing need to extend the built-up space.

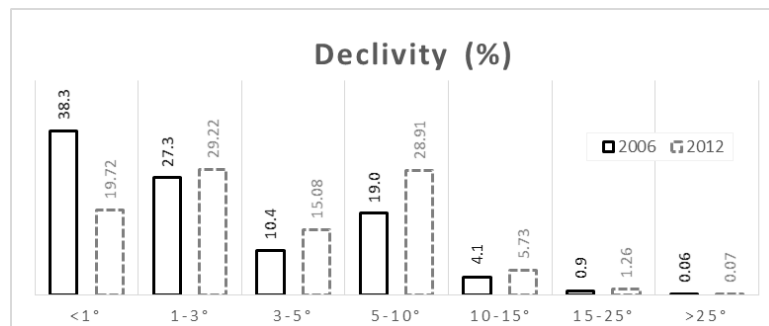


Fig. 8 - The distribution of built-up area according to the declivity

The **slope orientation** parameter is almost equally important for the favorability for construction, determining the relative amount of incoming solar radiation incident on the surface. This parameter is very useful when considering

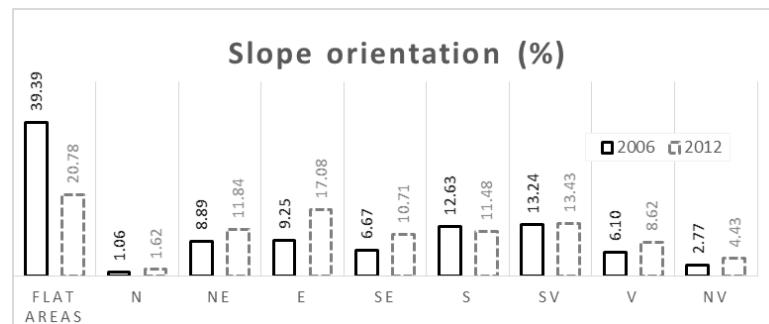


Fig. 9 - The distribution of built-up area according to slope orientation

building and terrain uses. The chart (fig. 7) highlights the favorability for construction of quasi-horizontal surfaces, but also can be seen important value differences between the two periods. If in 2006, most of the built-up areas (39,4%)

where found in the maximum class favorability, in 2012 can be observed a better distribution of values to the other favorability classes. The lowest favorability class for construction is represented by the Northern slope orientation, which is a “shaded area”, this fact being reflected in the lowest values recorded in the two periods. The analysis shows a general increase of the built-up areas in lower favorability classes (2006 – 2012), resulting that the territorial expansion reached a saturation level of the buildings in the most favorable areas. The main reason is the explosive population growth during this period, imposing the need to develop the built-up area on less favorable terrain.

Another factor that led to this phenomenon is the people’s desire to improve their lifestyle, having increasing demands in terms of housing, thus reflecting a growing need for space. The scale of this phenomenon has been driven by technological advances in recent years, which can provide large construction sites with high restrictiveness in terms of natural factors.

This category includes the built-up areas of Valea Lupului, which focused primarily in the most favorable areas, with low slope values (mostly 8 degrees) and on the slopes with a Southern orientation (fig. 8 - a.). Although one may see large changes of the built-up space configuration in 2006 – 2012 period, these changes were made independently from the previous period, which can be interpreted that the local areas still resist the real estate pressure.

Also, the other peripheral areas of Iasi city have recorded the same evolutionary pattern, where the built-up areas were expanded mainly in areas favorable from physical-geographical point of view. For example, the most of the new constructions in Valea Adanca were carried out in areas with low declivity (8-12 degrees) and South-South-East slopes orientation, with few exceptions due to Ezareni Lake, which acts as a favorable factor in terms of housing. In Miroslava, the reduced declivity (8 degree average) allowed the development of the built-up areas, with some exceptions, to the exit of Galata district, where the slope inclination degree exceeds 12 degrees. In Rediu, the low declivity values, but also the South-South-East slope orientation contributed to the favorability of the area in the North. In Breazu area, although the slope have a higher inclination (20 – 24 degrees), the forest and the good accessibility to Iasi city act as favorable factors.

A particular case is found in Dancu-Holboca area, where the constructions were built mainly to the North, as a result of certain restrictive factors, such as the wastewater plant – a permanent source of odor. The favorable factors were the presence of Chirita Lake and probably the modernized road. Also, the North expansion of the built-up area was favored by the low declivity, not exceeding 8 degrees, and the Southern slope orientation (fig. 8 – f.).

Generally, between 2006 and 2012 can be noticed an obvious increase of the built-up areas less bidding from natural point of view, which shows that the

expansion was realized as a result of reaching a saturation level of the building in the most favorable areas.

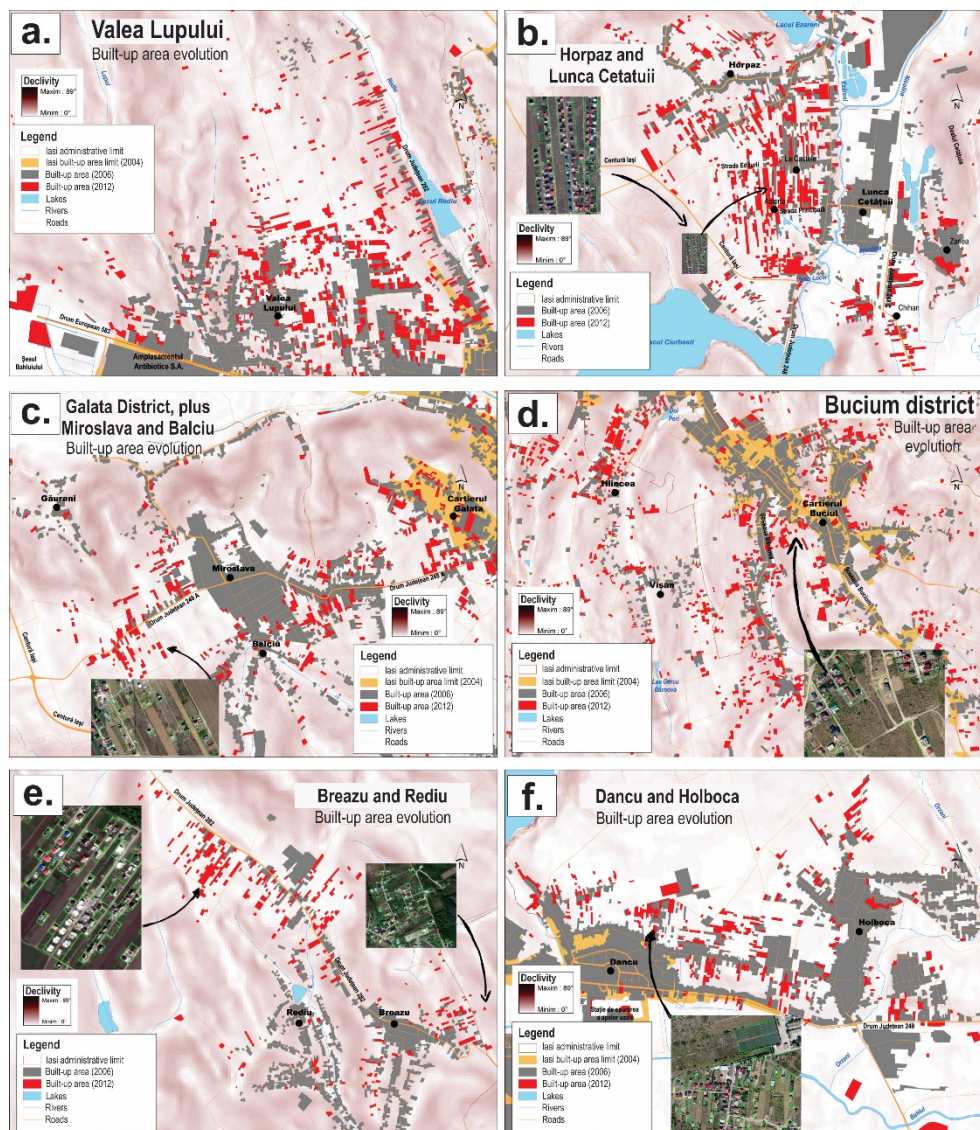


Fig. 10 - Selective images of the periurbanization process of Iasi city

The periurbanization phenomenon of the Iasi city has recorded a series of particular evolutions, appropriate to the local conditions. For example, in Lunca

Cetatuii area, whose overall development was chaotic, disregarding the soils quality, slope orientation (predominantly East), or declivity, factors that normally should lead to a more efficient land exploitation. This type of territorial evolution is the result of different projects of various real estate developers (fig. 8 – b.). A coherent periurban development requires that these investors to work together to prevent various infrastructural or even functionality problems. As we mentioned before, the only type of coherent development in this locality is the area near the ring road of Iasi city, recently modernized, thanks to the high degree of accessibility and the proximity to the recreational Ciurbesti Lake.

The proximity to areas with high landscape values, so called “recreational areas”. Some of the most representative examples are the concentration of the built-up area of Valea Lupului near Rediu Lake, attractive in terms of local leisure activities, or near European Road E 583, which act as dominant factors.

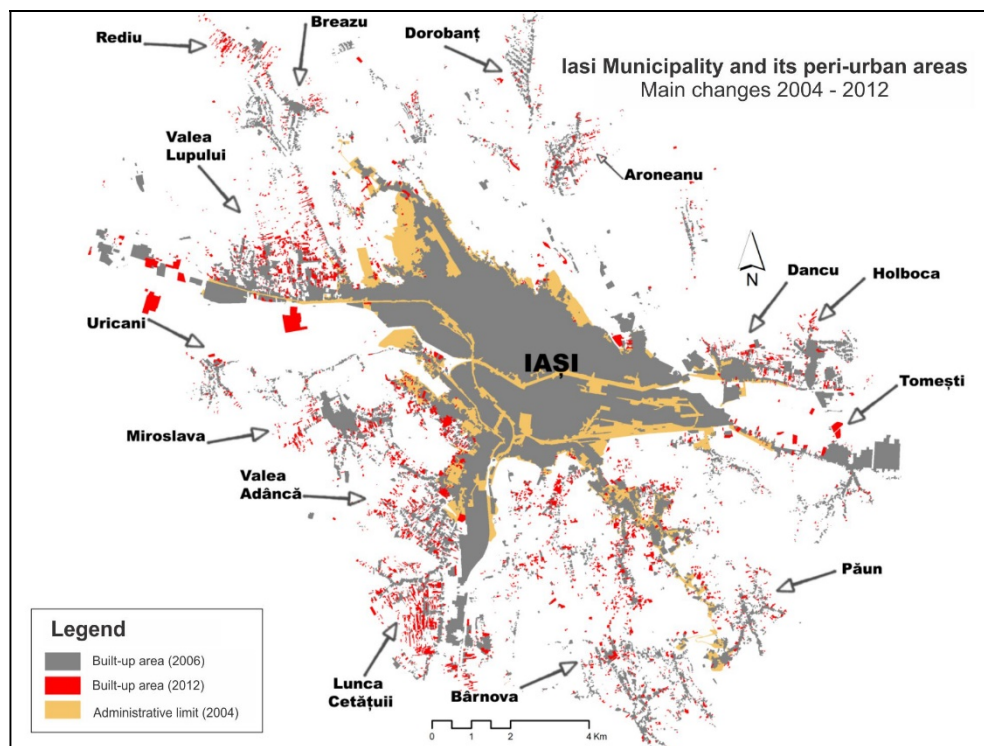


Fig. 11 - Territorial expansion of Iasi city

The city of Iasi and its surroundings does not lack of such types of attraction points, hence a concentrated series of constructions were built around these

objectives. In Valea Lupului area, the Rediu Lake favors the concentration of built-up area in the immediate vicinity, and in Horpaz and Valea Adanca the Ezareni Lake has left its mark on the new construction sites. Also, the territorial expansion of Aroneanu village can be attributed to the existence of Aroneanu and Dorobant lakes, and in Dancu and Holboca, an important role is played by the existence of Chirita Lake. In Rediu and Breazu areas, the most attractive factors for the development of new real estate projects was the forest and the low price of land.

The most spectacular development of the built-up area was recorded in the Bucium district, where the changes occurred at the expense of former vineyard surface areas (fig. 8 – d.). At first, the territorial expansion was carried out along the road axis, and afterwards, the development was made by connecting and densifying these areas after the administrative limit of Iasi city. The high degree of accessibility and the proximity to the main points of interest of Iasi city lead to the development of the constructions even on the less favorable areas in geomorphological terms (for example: 20 - 24 degree of declivity).

Conclusions

The analysis focuses on the changes of the built-up area of Iasi municipality and its peripheral areas, briefly investigating their diverse typology. The usefulness of the spatial typologies revealed is that, on it, can be build a strategy for intervention in the most sensitive or vulnerable areas, using them as a frame (Stan, 2013). The socio-economic and politico-administrative evolution of Iasi has deeply marked the urban landscape, forced to successive restructurings and adjustments (Stoleriu O. and Stoleriu C., 2004). The city of Iasi has known various types of development in recent years, marked by multiple functional changes of the main districts and the need for further expansion of the built-up area, as a result of the high pressure of housing.

The analysis showed that the presence of favoring factors coordinated the overall development of Iasi city and its peripheral areas. Thus, one can identify that there are certain dominant factors that mark the decision of developing a specific area. Due to technical solutions, more and more advanced in terms of construction, the natural factors such as geomorphology (declivity, slope orientation etc.) play a secondary role in choosing the area for construction, the main factors being the accessibility to the functional areas of the city, or the proximity to an area with special landscape quality.

One of the goals of the paper was to propose a methodology for analyzing urban dynamics in spatial and temporal terms, by considering the main characteristics of the urban patterns that lead to the development of the areas.

Based on these characteristics, the analysis was applied on two main temporal stages (2004 – 2006, 2006 – 2012), in order to detect the patterns of evolution.

The analysis and quantification of the urban system sprawl can provide a useful tool for visualizing future projections of growth patterns and underline those areas in which natural resources are threatened by this kind of growths (Colaninno N., et al., 2011). The results showed a continuous and rapid expansion of built-up area, with different growth patterns depending on the socio-economic factors, including population growth, processes of industrialization and urbanization etc., which represented the dominant driving factors of this phenomenon.

Urban development has been intensive and poorly controlled. To move towards a more sustainable configuration, the implication of all stakeholders in the municipality will be required. (Hewitt and Escobar, 2010). Thus, the knowledge that is acquired can be applied in planning procedures and can also provide basic information for improving the decision-making over the territory. (Chelaru et al., 2013).

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