Analysing the spatio-temporal evolution of built-up area in Bistrita subcarpathian valley using G.I.S techniques

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ABSTRACT

The goal of the study is to develop an appropriate method for analyzing and quantifying the territorial expansion of built-up area in the administrative territory of Bistrita subcarpathian Valley, a well populated region. The area under study has high favorability in terms of housing due to its contact geographical unit position and access to natural resources. Analyzing spatio-temporal dynamics of built-up area is essential for understanding and assessing the consequences of anthropogenic pressure on the environment. The methodology was mainly achi sved through GIS techniques, by using relevant cartographic documents covering a period of more than 200 years. As a particular method we created a system of matrices (focalsum) which divide the areas affected by changes into equal size squares in order to highlight the density of these changes. The study was conducted through a systemic approach, aiming to analyze the connections between the territo: ial expansion and the environmental components which constituted key factors to its dynamics. The results showed a continuous and rapid expansion of built-up area, With different growth patterns depending on the socioeconomic factors, which represented the dominant driving factors of this phenomenon.

Keywords: built-up area evolution, anthropogenic pressure, GIS, Bistrita Subcarpathian Valley, Romania

INTRODUCTION

The necessity of the present study is given by the importance of human interventions on the environment. One of the aspects concerning the anthropogenic impact lies in the continuous expansion in time and space of built domain [1], 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.
Consequently, the goal of this paper is to provide a research framework and methodologies that contribute to the understanding of sprawl dynamics [2], The accelerated industrialization and urbanization following economic reforms and population increases have greatly affected land-use change through the increase of built- up areas and urban sprawl [3], [4],

The area under study is located in the East of Romania, being part of the Moldavian Subcarpathians sector and having as main limits the Oriental Carpathians in the West and the Siret corridor in the East. It is a well populated region, extended over a length of approximately 50 km, characterized by large terraces, and has a high favorability in terms of housing due to its contact geographical unit position and access to natural resources.

DATA AND METHODS

Due to the use of cartographic materials from different periods and at different scales, the analysis of environmental components was made from two perspectives: qualitative and quantitative. The analysis of cartographic documents was realized both from a static point of view, in which the elements were analyzed as a whole in each map and dynamic, which tracked the evolution of each component [5], The analysis of the territorial expansion and the density of these changes in Bistrita subcarpathian Valley was conducted into the GIS environment, using the following cartographic documents: 1:56.000 scale Austrain maps - 1788/1790, 1:20.000 scale Military Survey maps - 1917, 1:10.000 scale cadastral plans - 1986, 1:5.000 scale topographic plans - 1975/1976, and the orthophotomaps at 1:5.000 scale obtained from ANCPI (National Agency for Cadastre and Land Registration). This string of maps was used to create de DEM (digital elevation model) at 5 meters resolution for analyzing the geomorphology on which are located the settlements, and all the other vector layers required in the analysis (hydrography, built-up area etc.)

The qualitative analysis was applied to the use of all strings of maps at close scales available, from the austrian map made in 1788/1790 to the aerial imagery from current period. The goal of utilizing these maps is to capture certain patterns of evolution, and to explain the causes of these phenomena. Although we experienced some geometric mapping errors, different projection systems, some of the maps being non-unitary and made for specific purposes, all cartographic materials allow us to extract some common features. From their analyse we can highlight the areas that remain constant, but especially those who have a pronounced dynamics. The quantitative analysis is based on geostatistical methods to quantify the areas affected by changes. Applying this method shows satisfactory results and, by their correlation with different events and natural phenomena, socio-economical, historical, political or others we can highlight the causes that led to these changes [5],

To get a general image of the dynamic areas in spatio-temporal terms throughout the period under review regarding landscape configuration changes, we used GIS techniques, namely the "squares method" (focalsum - a grid system which divides into equally sized squares the areas affected by changes in order to highlight the density of these changes).

Although the chosen method does not entirely reflect the reality on the ground, meaning that the old cartographic materials can't provide accurate data, it is the only possibility to analyse the areas with changes. Thus, to have a time guideline, we have used as measure unit a surface which consists of a square, having in this case an area of 1 square kilometer. For analysing the changes of settlements in Bistrita subcarpathian Valley we have performed such a matrix for three periods based on the existing cartographic documents.

RESULTS AND DISCUSSIONS

In the resulting cartographic materials we chose to highlight only the areas covered by changes, putting them in relation to other environmental components which constituted key factors to its dynamics. In order to emphasize the density of changes each square is coloured differently depending on the percentage affected by changes in the perimeter. As it can be seen, the main factor that influenced the territorial expansion of built-up area in the territory under study is Bistrita river. First period under investigation (fig. 1) showed that Bistrita represented the main restrictive factor because it had large level variations, so that the inherent floods were devastating and significantly altered the riverbed configuration. Thus, by the fact that Bistrita river acted as a communication axis of highly importance regarding the economic life of the territory, but also by its restrictiveness for conducting certain human activities, it represented the most important factor for the socio-economic development of the area.

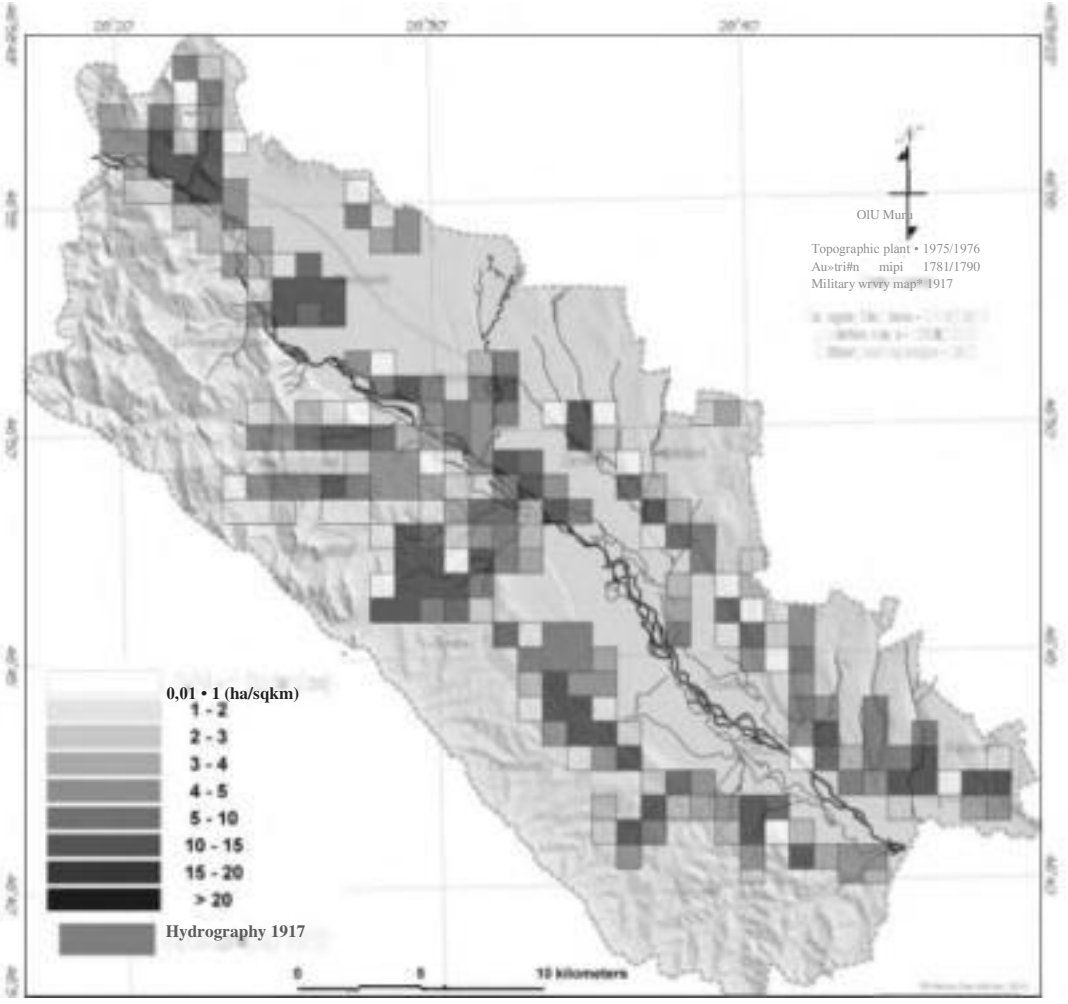

Fig. 1 - The density of built-up area changes between 1788/1790 - 1917

The first resulting map covers a period of over a century and is characterized by the nuclei shaping of settlements located on areas favourable for housing in geomorphological terms and at a safe distance from the flooded area of Bistrita river. There is a high density of built-up area expansion of over 20 ha/sq km mainly in Piatra Neamt area municipality, but also in the settlements on the left side of Bistrita such as Dumbrava Rosie, Roznov, Zanesti, Buhusi or Racova, on the 10 - 17 meters, 20 - 25 or 70 meters terraces. On the right side of Bistrita, the expansion was made especially in the proximity of Calu, Iapa or Nechit tributaries, the higher density being found in Borlesti.

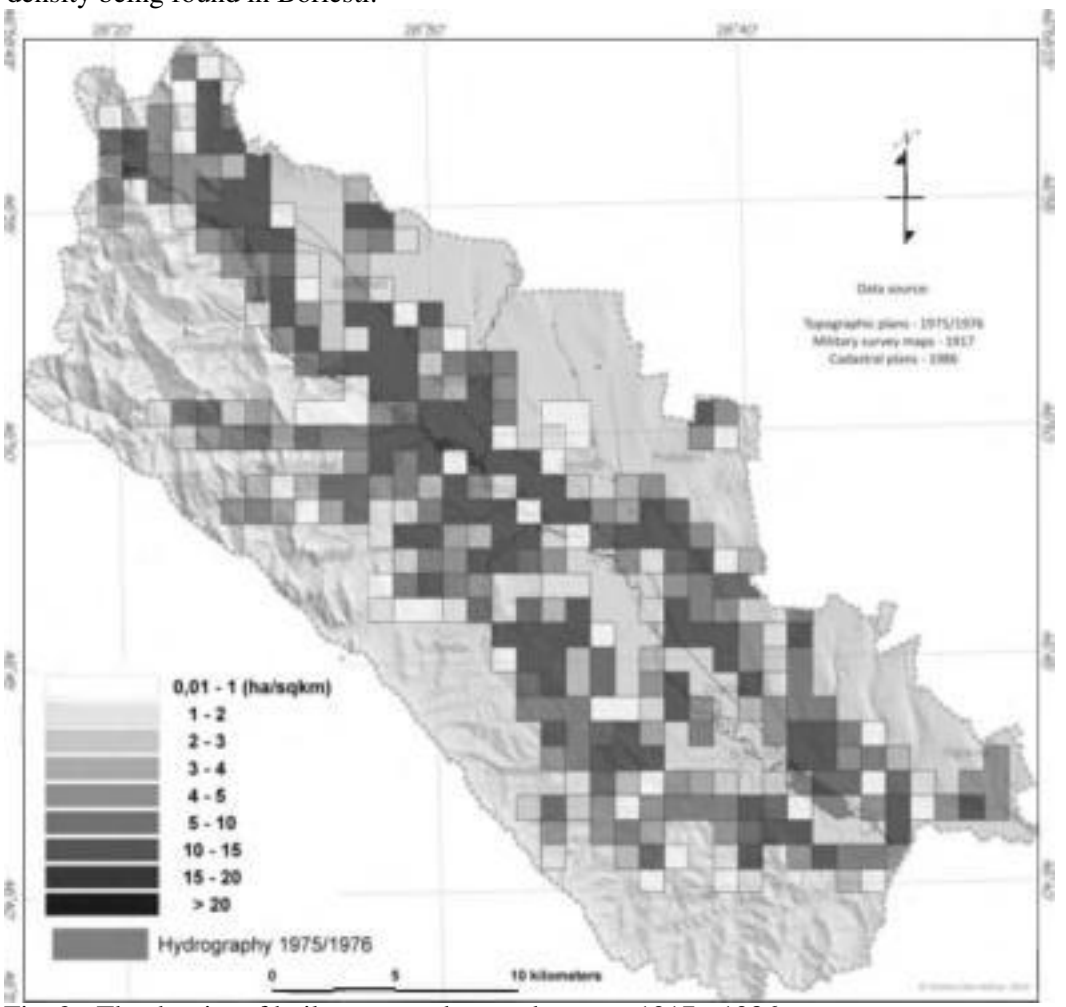

Fig. 2 - The density of built-up area changes between 1917 - 1986

The analysis of the second period shows a major expansion of built-up area, due to a combination of natural, but also socio-economic factors. The most important driving factor remains the hydrographic one, where Bistrita river has suffered major modifications through human intervention, its main course being diverted through a channel of 30 kilometers length for hydropower purposes. Starting 1960, the devastating floods disappeared and Bistrita river was no longer such a restrictive driving factor for the expansion of built-up area. Consequently, the built-up areas were mainly extended along Bistrita river especially due to hydrotechnical works that provided for the first time a continuous source of electricity for the entire country. At a closer look, one can observe three main nuclei in which the density of built-up area expansion is very high, the dominant values having over 10 - 15 ha/sq km. This is due to the forced industrialization phenomenon, imposed in the socialist years, in which were created

large industrial platforms (in this case at Piatra Neamt, Savinesti-Roznov and Buhusi). At that time, these industrial sites represented real "engines" of the territorial socioeconomic development and therefore of the territorial expansion. Instead, it appears that the density values with less than 3 ha/sq km have a small proportion of the total and those areas can be identified generally at the outskirts of the settlements, on surfaces less favorable for housing.
The most recent investigated period (fig. 3), which is the shortest (approximately two decades), observed that the density of built-up area changes is relatively constant throughout, with minor exceptions, in which the natural driving factor has limited its restrictiveness close to zero, mainly due to unprecedented technological development. Unlike the previous period, the prevailing density values of the expansion fits into the smaller classes, mainly between 0,01 to 4 ha/sq km.

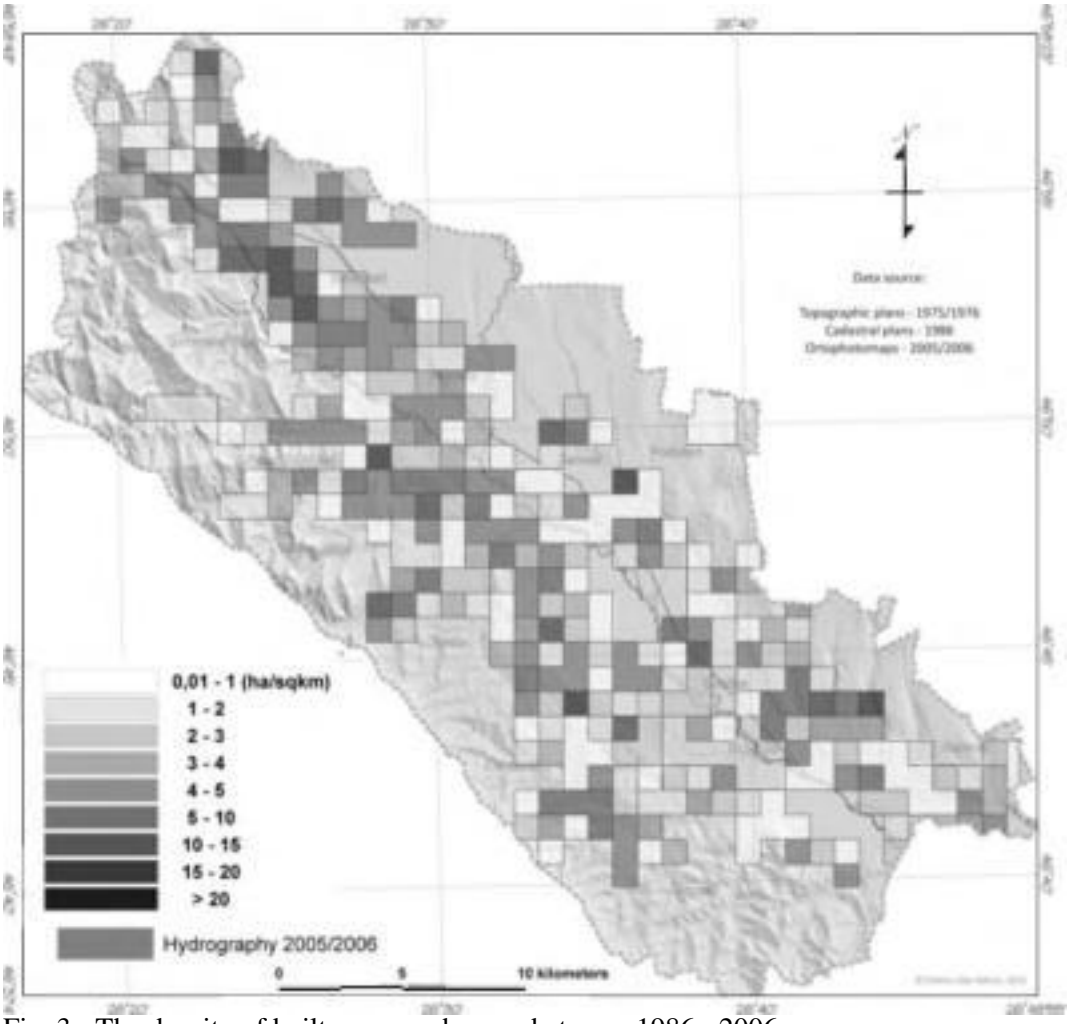

Fig. 3 - The density of built-up area changes between 1986 - 2006

The exception mentioned above can be found in Piatra Neamt municipality proximity, especially in SE (Dumbrava Rosie), where the land meets current requirements of increasing comfort indicators in private housing, and have a good accessibility to the main social, economic or other type of attraction (in this case, Piatra Neamt).

According to the graphic resulted from processing the 3 cartographic materials achieved (fig. 4), during the first period (1788 - 1917), although the expansion was not carried out over large areas, it is noted that the highest share in terms of built-up area changes density is held by the class of over 20 ha/sq km, which has 7,81 % of the total analysed area. This shows the compactness of settlements of that period.

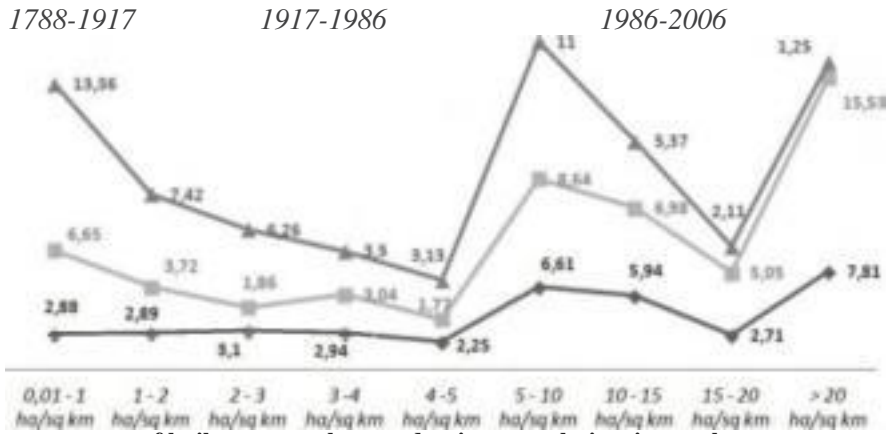

Fig. 4 - The percentages of built-up area changes density on each time interval

The second time interval coincides with the period of the great socialist constructions which, in conjunction with the intensive development of the industry, resulted in an unprecedented socio-economic development. Thus, during this period we are dealing with the highest density values from all over the analysed period. This can be seen by very high share of the classes of over 5 - 10 ha/sq km, being emphasized the over 20 ha/sq km class, with 15,53 % of the total.

Because the last period under study is shorter, there is a significant decrease in the density of extended built-up areas, the maximum value being assigned to 5 to 10 ha/sq km class. The areas with a density of more than 20 ha/sq km, unlike the other two periods, has values of only 1,25 %. The expansion was carried out disseminated over the territory, without large and compact new built-up areas. This results from the fact that the highest density of built-up area expansion (13,36 %) falls into the first class (0,01 - 1 hectare/square kilometer).

The analysis of built-up area evolution has an important role in the assessment of anthropogenic pressure on the environment, having the highest growth rate regarding changes of land use categories. After processing the cartographic materials and the field data was observed that the territorial expansion of built-up area was made mainly at the expense of arable land and secondary of pastures.

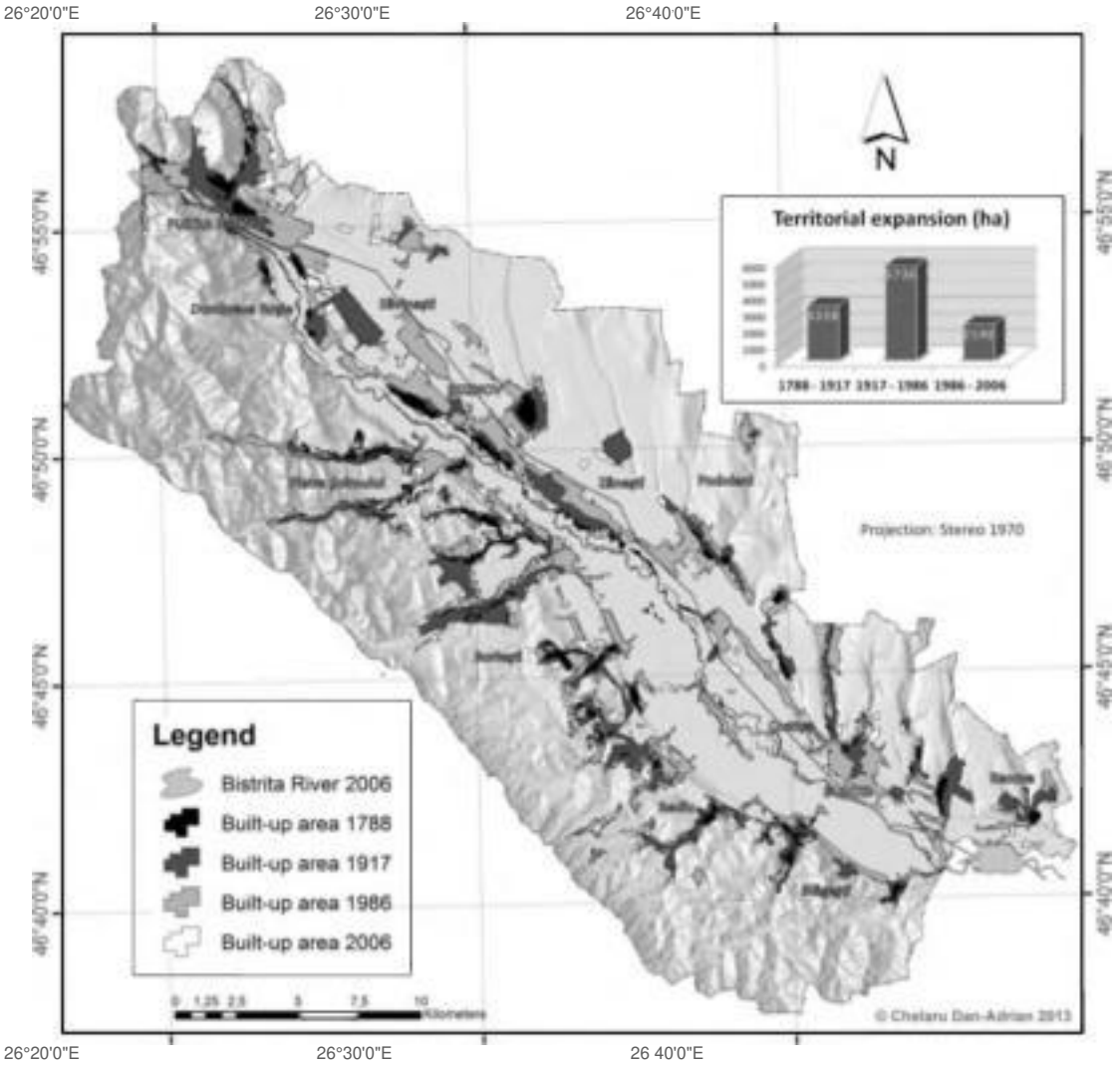

Fig. 5 - Territorial expansion in Bistrita subcarpathian Valley - administrative limit

Following the geostatistical analysis of the territorial expansion map (fig. 5) is distinguished the last period (1986 - 2006), in which the built-up area extended with 2.190 ha, especially due to demographical factors. The causes can be found both before the fall of the communism and after. Thus, if prior to 1990 the territorial expansion was largely done through the rapid process of industrialization, being developed some new industrial sites, in the next period this expansion was done due to the population desire of increasing the comfort indicators [5], [6], During the last two decades has been recorded a slow demographic dynamics, leading to significant population number decline, especially after the year 2000, when due to the economic stagnation and even regression, industrial privatization and mass layoffs, the registered unemployed number increased resulting in searching for a job in other cities, or emigrating. As a consequence of emigration, the territory has experienced an unprecedented real estate development, the number of housing increasing constantly.

CONCLUSIONS

Based on a systemic approach, the study revealed the behavior of natural and anthropogenic driving factors of the landscape system, which, by their functional mechanisms of response to each other's actions, have caused permanent changes to the current state of the landscape. Thus, if the Bistrita river affected decisively the human factor through restrictiveness, in turn, the human factor had to find answers for the proper functioning and socio-economic development, gradually changing the configuration of the natural factor, and unfortunately its quality by polluting actions. Concerning our analysis, some remarkable changes have been recorded, not only over the entire investigated period, but also between the individual time horizons [7], 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. The knowledge that is acquired can be applied in planning procedures and can also provide basic information for improving the decisionmaking over the territory.

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REFERENCES

[1] Vartolomei F. & Armas I. The intensification of antropic pressure through the expansion of the constructed area in the subcarpathian sector of the Prahova Valley (1800-2008), Forum geograph § Romania, vol. 9, pp. 125 - 132, 2010.

[2] Batisani N. & Yarnal B., Urban expansion in Centre County, Pennsylvania: Spatial dynamics and landscape transformations, Applied Geography, 29, pp. 235 - 249, 2009.

[3] Wu L.X., Sun B., Zhou S.L., Huang S.E. & Zhao Q.G., A new fusion technique of remote sensing images for land use/cover, Pedosphere, 14 , pp. 187-194, 2004.

[4] Long H., Tang G., Li X. & Heiling G., Socio-economic driving forces of land-use change in Kunshan, the Yangtze River Delta economic area of China, Journal of Environmental management, vol. 83, issue 3, pp. 351-364, 2007.

[5] Chelaru D.-A. & Apostol L., Using GIS to analyse land use change in Bistrita Subcarpathian Valley, Present Environment & Sustainable Development, Romania, Vol. 6, No. 2; pp. 315 -325, 2012.

[6] Apostol L. & Chelaru D.-A. (2011), The landscape dynamics in Piatra Neamt area, Present Environment & Sustainable Development, Romania, Vol. 5, No. 2, pp. 89 - 100, 2011.

[7] Chelaru D.-A. & Apostol L., Ursu A. (2013) - *in press* - Spatial analysis of forested area dynamics in Bistrita Valley - subcarpathian sector, Present Environment & Sustainable Development, Romania, Vol. 7, no. 11, 2013.