LAND USE CHANGE DYNAMICS IN THE UPPER AND MIDDLE RIVER BASIN OF THE STREI VALLEY

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Key words: land use change (LUC), rate of change, backwards mapping, deforestation rate, intensification of agriculture, the upper and middle basin of the Strei river.
Cuvinte cheie: modificarea modului de utilizare a terenurilor, rata de conversie, cartografiere retrospectivă, bazinul mijlociu şi superior al Streiului, rata despăduririlor, extinderea terenurilor agricole.

ABSTRACT:

Land use change assessment is an interdisciplinary approach, and also, a "key factor" in environmental impact identification caused by anthropogenic activity. In this respect, cartographic materials from three distinct periods were used which allowed data base construction and a staged analysis of the land use change taking into consideration the factors which triggered the conversions. On the maps obtained, the rates of change were calculated and the areas, where the same land use persists for more than 200 years, were identified.

1. Introduction

The research regarding the land use change (LUC) has become increasingly common in recent decades. In the international literature, the land use change and its environmental effects on other components were analyzed by: Bilsborrow şi DeLargy, 1990, Li and Sun, 1997, Verburg et al., 1997, Ramankutty şi Foley, 1999, Lopez et al., 2001, Achard et al., 2002, Hall et al., 2002, Weng, 2002, Mas et al., 2004, Verburg et al., 2004, Kiss et al., 2005, Lopez et al, 2005, Riedel et al., 2005, Vatsava şi Stoimenov, 2006, Flamenco-Sandoval et al., 2007, Vamos şi Barrany, 2007, Al-Hassideh şi Bill, 2008, Cheng, 2008, Xuying et al., 2008, Hegedus şi Duray, 2009, Solaimani et al., 2009, Ferenac et al., 2010, Ganzei et al., 2010, Gől et al., 2010, Taylor et al., 2010 etc.

Using cartographic materials from different periods and statistical methods, they analysed the effects of the land use change on landforms, on river discharge, on fluvial and geomorphological processes, etc.; they established relationships between changes and the factors that triggered them, and mentioned the ameliorative measures undertaken. They also calculated the rates of conversion and elaborated predictions on how land use changes.

In our country, few researchers have had concerns in this regard, and only in recent years, probably due to lack of information sources (eg cartographic materials), which allow such analysis (Ursu et al., 2007, Cojocaru et la., 2008, Osaci-Costache, 2007, 2009, Popovici et al., 2010 etc.).

2. Methodology

Land use change is an interdisciplinary approach, in which one must answer the following questions: "*Who*?" "*What*?" "*When*?" "*Where*?" and "*Why*?". In all studies elaborated up to date, land use change has been analysed from a historical perspective, using GIS techniques and statistical means, taking into account the triggering factors. To answer the above questions, in this study, we aim to:

• *build a database using cartographic materials from different periods and GIS techniques*;

To highlight the land use change, we used backwards mapping based on large-scale topographic maps. We used Austrian maps, scale 1:28.800 (1806-1869), topographical maps, scale 1:25.000 (edition 1963) and orthophotoplans (resolution 0.5 m) (2005). We also took into consideration soil maps made by the Office for Soil and agrochemicals Survey, Deva, from 1976, 1983 and 2007, and the forest plans for Baru, Pui, Retezat and Haţeg forest districts (2006-2007).

• *establish classes regarding the land use, taking into consideration the cartographic materials, and identify the conversions*;

The cartographic materials from different periods have conditioned the classes establishment. In addition, the intention was to enhance different processes such as deforestation, afforestation, hydro-ameliorative works, erosion works, grubbing , built surface extension etc. Five classes were established. Each class received a code from 1 to 5. These classes include heterogeneous surfaces as far as the use is concerned, which in turn received a code.

• *compare the maps obtained to evaluate the land use*;

Map comparison is a straightforward method for assessing the changes and one must take into account characteristics such as scale, classification, accuracy and the mapping method (Mas et al., 2004).

• *calculate the rate of change;*

Once the areas of land use types were obtained for each period, the *rate of change* (r) was calculated, by using the following equation:

$$r = \left(\frac{A2}{A1} \right)^{1/t} - 1$$

where *A1*-the area with a given land use at time 1; *A2*-area at time 2, *t*-the number of years for the period of analysis;

• *estalish a correlation between land use and the factors which cause its change*;

• *identify and analyse the spatial distribution of the changes*;

• *identify elements of toponymy on the maps which reflect the land use*;

3. Results and discutions

Database construction. The maps were digitized. The polygons of the different land use classes from 1806-1868 were labeled according to the class

they belong to. Once this map was made, the polygons were copied and those that required changes were adjusted according to the maps from 1963, adding, erasing or modifying, to reflect the changes produced in this period. In this way, we obtained the land use for 1963. The same procedure was used for the third map to avoid generating false changes due to differences in the delimitations of the same elements in two different periods (Achard et al., 2002, Mas et al., 2004, Flamenco-Sandoval et al., 2007).

This database can be used in combination with other thematic information (socio-economic factors, spatial-environment databases) for regional planning and environmental management (Vatseva and Stoimenov, 2006).

Land use change dynamics and triggerring factors. Changes have occurred in time and space and, therefore, one needs to establish correlations between the changes and the factors that triggerred them. The relations between them depend on the scale of observation (Verburg et al., 1997) and are not the same in all cases. In general, most authors took into account the demographic factors, the economic policies and the changes induced by the anthropogenic factor.

1. Demographic factors. Migration, population growth and demographic phenomena, such as aging or feminization, significantly affect the economic activities and trigger changes on the land use (e.g. the expansion of the arable land and of the built areas to the forestred areas' detriment, arable land abandonment etc.). Some of these issues have been examined internationally in several case studies (Bilsborrow and Delargy, 1990, Li and Sun, 1997, Lopez et al., 2005, Vamos and Barrany, 2007, Xuying et al., 2008, etc..).

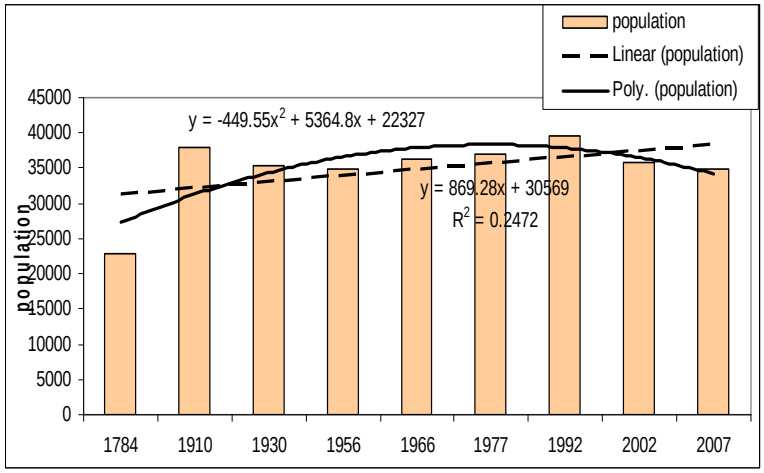

Fig.1. Evolution of the number of inhabitants in the upper and middle basin of the Streiului valley.

During the period under review, there is a significant increase in the number of inhabitants (Fig. 1), which shows the obvious influence of the population on the land use dynamics.

2. Changes induced by anthropogenic factors: deforestation, afforestation, grubbing, economic activities (agricultural, industrial subsoil resources exploitation), implementation of infrastructure works, hydro-ameliorative and anti-erosion works etc..

3. Agricultural reforms and economic policies. During the period under review, the following land reforms were conducted, which have changed the ownership and, consequently, the land use:

a) the land reform of 1921, which limited the properties to the highest level of 500 ha; the lands that were owned by the noble families (Kenderesy, Kendeffy, Csulay, Pogany, Nopcsa etc.), by the church and local owner associations were passed to the state ownership, by paying compensationsp, then they were redistributed to peasants by selling them;

b) the land reform of 1945 rescaled the agricultural property, but did not change the small and medium-sized farms; the land redistributed to peasants was from dismembered big land-owned properties;

c) during 1949-1962 the cooperativisation process took place; through it, the land passed from private ownership to common management;

d) after 1963 and until 1989, there were three farm types: *private agricultural farm*, with small agricultural area and production; *cooperative farm*, which owned the land and labor resources from the merging of private households in small and medium enterprises; *agricultural state firms* organised in farms, whose property consisted of nationalized land, that had belonged to large estates;

In addition, *inter-cooperativist economic associations* were established in 1970s, specialized in a particular production sector.

e) after 1989, the ownership is clarified (Decree-Law 42/1990 and Law 18/1991) and the private farming principles came back;

Law 18/1991 has led to a steady degradation of land and the failure of the implementation of sustainable and competitive farming practices as a result of changing the type of property. In the Haţegului Depression the average size of land ownership is of 3.6 ha of agricultural land (above the country average of 2ha), but it is divided into a number of parcels (Popa, 1999). Under 2ha plots are spread among households and between pastures and forests on the slopes.

4. Inappropriate agricultural practices: overgrazing, orchard deforestation, farmland abandonment, etc..

5. Natural factors (e.g. river bed dynamics: the abandoned river beds, currently are occupied by hydrophilic vegetation);

Land use change assessment. We identified conversions both among classes (agriculture-forestry, forestry-agriculture, agriculture/forest- built areas or water bodies) and within the same classes (most have occurred in agriculture and forestry) (figure 2).

For the period 1806-1868-1963, we noticed (figures 3 and 4):

- the artificial areas increased from 1.07% of the territory to 1.71%; this increase is obvious in the case of Haţeg town;

- the forested areas decreased from 76.16% to 74.85% due to the increase of agricultural areas from 22.65% to 23.19% (e.g. the right side of the Strei river around Fizeşti and Federi, on the right side of the Galbena river around

Răchitova, Stei, Poieni, Mesteacăn etc., on the interfluve between the Sibisel and the Râu Mare etc.);

- the extension of the built areas resulted form the shrinkage of the orchards that extended around settlements (this is the case of all settlements in rural areas);

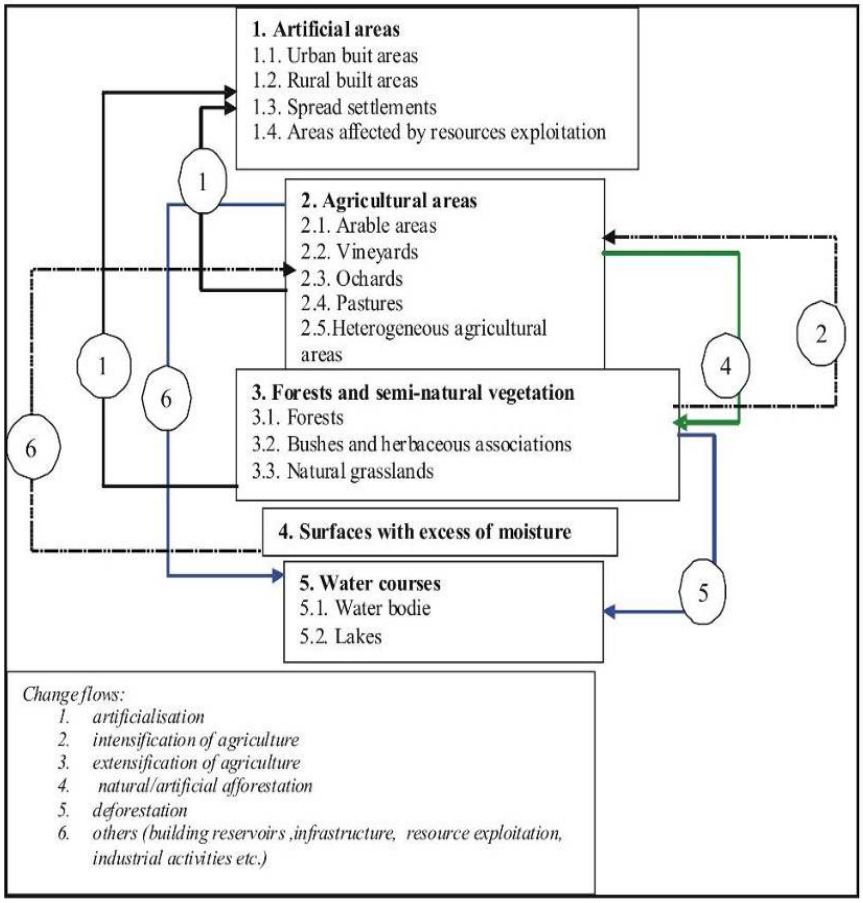

Fig. 2. Land use change flows and processes.

- in 1806-1868, there is a uniformity in the land use caused by ownership; arable lands were outside the settlements;

- the rates of change are low: 0.01% (rate of deforestation), 0.014% (rate of the agricultural land expansion) and 0.28% (rate of artificiality);

- in the dynamics of the land use, we identified the following trends: the conversion of forested areas to agricultural ones (e.g. the interfluves between the Râu Bărbat and the Râu Alb) and irreversible removal from the agricultural circuit of the lands to extend the artificial areas;

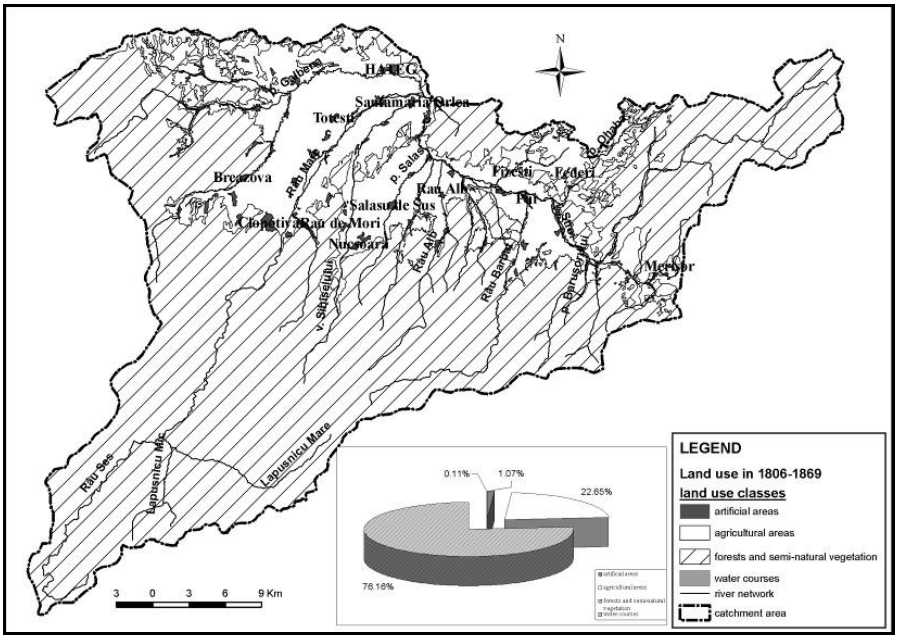

Fig. 3. Land use in 1806-1869.

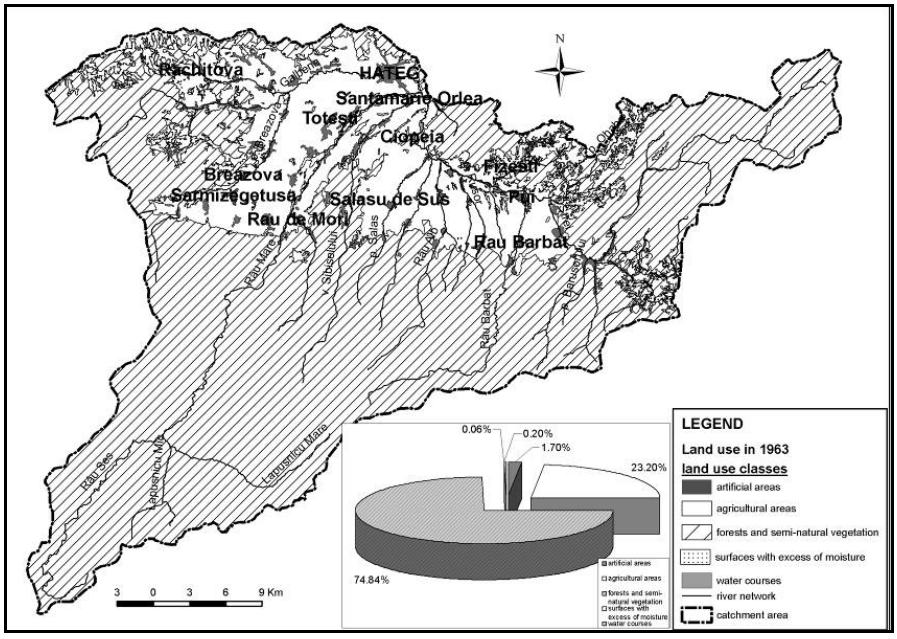

Fig. 4. Land use in 1963.

For the 1963-2005 period, we noticed (figures 4 and 5):
- artificial surfaces increasing to 1.96% of the catchment area and the permanent removal of certain areas from the agricultural and forest circuit by extending the built areas and the hydro-energy works on the Râu Mare;
- descending trend of forest cover and withdrawal of the lower limit of forests;
- ascending trend of heterogeneous agricultural areas due to the type of ownership; there is an alternation of arable lands, pastures, meadows and orchards;
- the rates of change are higher compared with the previous period: 0.32% rate of artificiality, 0.11% rate of agricultural land extension, 0.048% deforestation rate; 1.48% rate of water bodies expansion;

By comparing the maps from different periods, we were able to identify areas which prevailed in the same manner of use. Thus, there is permanent agricultural use of land around settlements, and forestry in hilly and mountainous areas.

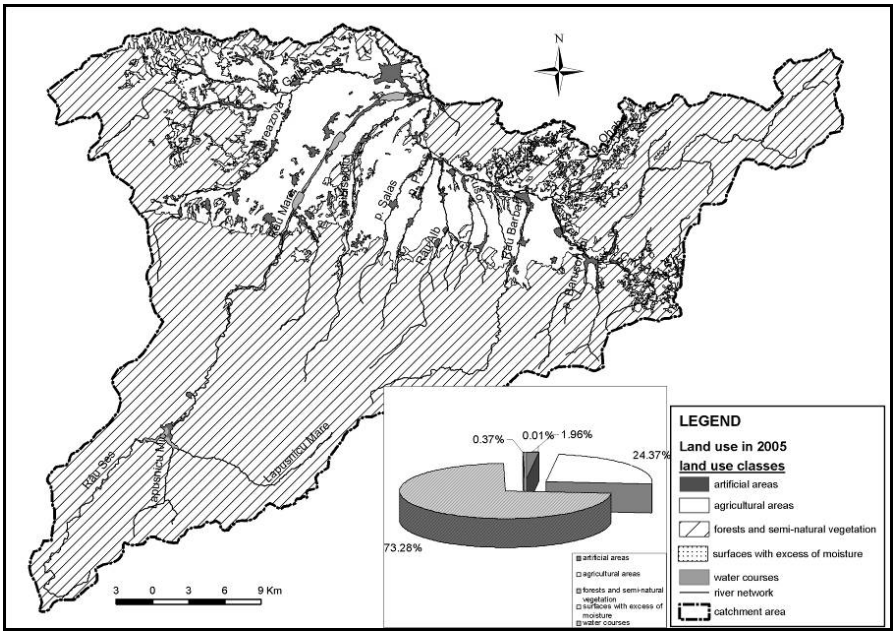

Fig. 5. Land use in 2005.

Toponymy reflects land use. Many place names recall the current enlargement process of anthropogenic areas and the dissemination of habitats (Boiţa (> "boişte" = place with logs) Ciopeia (> "cioplan" = old tree in a glade), Poieni, Livezi, Livadia (free woody vegetation sites or from which it was removed to make room for other uses), etc..), the prevalence of certain species of plants (Zăvoi, Copaci, Breazova (= birches), Mesteacăn, Răchitova etc.), and crops that have predominated (Malaiesti-surface planted with maize = corn).

4. Conclusions

Using cartographic materials from different periods, we were able to reconstruct how the land has been used for nearly 200 years, and identify the conversions on stages. It was found that artificial surfaces, agricultural and water bodies had an ascending trend in contrast to those forested which have retreated at every stage.

In the present study, errors could occur (that we assume) caused by the interpretation of cartographic materials from 1806-1869 caused by the accuracy with which they were made, the symbols that were used and by the fact that the mapping activity extended over a period of 63 years. Also, errors could occur in building the database, taking into account that to build a land use we had to start from a map made previously. In this way an initial error on a map could be perpetuated. Other errors may be generated by the establishment of classes, including areas with a specific use and the calculation of the rates of change.

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