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Indicators of the Human Pressure on the Environment in the Bălăciţa Piedmont

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Abstract
The Bălăciţa Piedmont represents the western subdivision of the Getic Piedmont, being located in south-western Romania.
The unit under study is an early inhabited space and, at the same time, an area of active development of numerous geodynamic phenomena. The man-induced changes had significant influences upon the environment and especially upon the relief, the increased vulnerability of the terrains to the dangerous geomorphologic phenomena being one of the most important problems that the local communities have to face nowadays.
The present study aims to assess the human influence upon the emergence of environmental unbalances and especially the human actions that influence the risk geomorphologic processes.
A relevant means in the process of evaluating the type and dimension of the human intervention within a given territorial unit concerns the computation of certain synthetic indicators that characterize the degree of landscape transformation. The assessment has been realized through the analysis of statistical data at the level of the administrative-territorial units that overlap the Bălăciţa Piedmont. The general research regards an interval of thirty years (1977 - 2007), while the focus was laid upon the transition period (1992, 2002, and 2007).

Keywords: human impact, human pressure indices, land use, land cover, deforestation, land degradation.

Rezumat. Indicatori ai presiunii umane asupra mediului din Piemontul Bălăciţei.
Piemontul Bălăciţei reprezintă subdiviziunea vestică a Piemontului Getic, fiind localizat în sud-vestul României.
Unitatea analizată reprezintă un spaţiu de veche locuire şi, în acelaşi timp, o arie de dezvoltare activă a numeroase fenomene ce modifică relieful. Transformările induse antropic au avut influenţe semnificative asupra mediului şi în mod special asupra reliefului, vulnerabilitatea tot mai ridicată a terenurilor la fenomenele geomorfologice periculoase fiind una dintre cele mai importante probleme pe care le au de înfruntat comunităţile locale în prezent.
Lucrarea de faţă îşi propune să evalueze influenţa antropică în apariţia dezechilibrelor de mediu şi, în mod particular, activităţile umane care influenţează procesele geomorfologice de risc.
Un mijloc relevant în evaluarea tipului şi dimensiunii intervenţiei antropice într-o unitate teritorială dată se referă la calcularea unor indicatori sintetici ce caracterizează gradul de transformare a peisajului. Evaluarea a fost realizată prin analiza datelor statistice la nivelul unităţilor administrativ-teritoriale ce se suprapun Piemontului Bălăciţei. Cercetarea generală are în vedere un interval de treizeci de ani (1977 - 2007), iar analiza particulară se referă la perioada de tranziţie (1992, 2002 şi 2007).

Cuvinte cheie: impact antropic, indicatori ai presiunii umane, modul de utilizare şi acoperire a terenurilor, despădurire, degradarea terenurilor.

INTRODUCTION

The Bălăciţa Piedmont represents the western subdivision of the Getic Piedmont, is located in south-western Romania (Fig. 1) and constitutes a monocline structure sloping by 2 - 3 degrees from north-west towards south-east. It is made up of fluvial - lacustrine deposits (sand, gravels, clay and marls) and coal intercalations, while the surface structures are of Quaternary age.

The unit under study is an early inhabited space and, at the same time, an area of active development of numerous geodynamic phenomena that modify the relief. The clearing of century-old forests led to land degradation and to an increased fragmentation of the relief. The diversification of economic activities and the intensification of the agricultural ones modified numerous characteristics of vegetation and soils. The man-induced changes had significant influences upon the environment and especially upon the relief, the increased vulnerability of the terrains to the dangerous geomorphologic phenomena being one of the most important problems that the local communities have to face nowadays (Stroe R., 2003; Boengiu S., 2008).

The present paper aims to assess the human influence upon the emergence of environmental unbalances and especially the human activities that could influence the hazardous geomorphologic processes. Further research will correlate the

findings of the present study with the type and spatial extension of these processes, as well as the reverse impact exerted on the human communities and activities in the Bălăciţa Piedmont.

Besides the scientific value of the research, one of the practical objectives of the study aims at raising the awareness of the local communities upon the importance of a good management of the environmental components. Close connections are established between them and the fact that the unbalances produced at a given level have unpredictable geomorphologic effects should be understood by the local communities while the local authorities should integrate the results of the scientific research in the environmental politics.

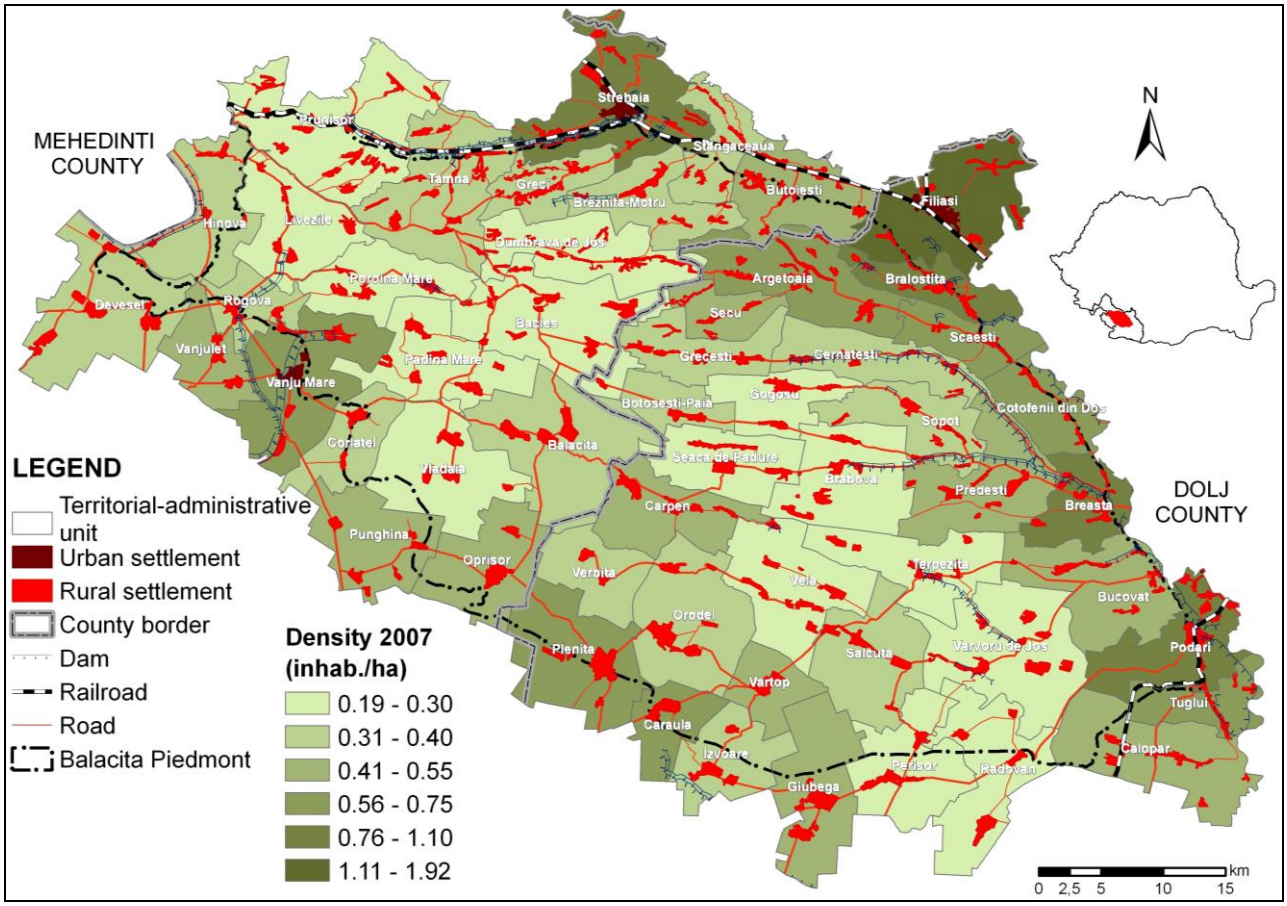

Fig. 1 The Bălăciţa Piedmont. Demographic – administrative features and infrastructure

MATERIALS AND METHODS

The analysis of the environmental components has been conducted based on the topographical maps scale 1:25,000, forest arrangement maps, and 2005 orthophotos. For the transition period, the Corine Land Cover database of the European Environment Agency was valorised in GIS environment and enabled a more detailed image of the land use dynamics correlated with the environmental transformations. There was achieved a complex database that comprises the above-mentioned maps (georeferenced), vector data (the transportation network, the built-up surfaces, the network of channels and levees, land use etc.) with the attributes necessary for the analysis, as well as statistical tabular data.

A combination of quantitative and qualitative exploration of different data sources improves the interpretability of the anthropogenic impacts. This combination has emphasis on the qualitative spatial analysis (visualizations). Visualizations seem adequate for the interpretation of the anthropogenic evolution of time-series changes (Tomaž Podobnikar et al., 2009).

Statistical analysis allowed for a better understanding of the human influence on the landscape transformation and on the appearance of environmental unbalances. This analysis was conducted in order to point out the level and the type of human stress on the landscape of the Bălăciţa Piedmont. Its second aim concerns the possibility of drawing recommendations in the framework of the living standards introduced by E. P. Odum and H. T. Odum in 1972. They regard the fact that an adult

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needs two hectares of terrain, the optimal structure of which being the following: unmodified natural surface – 0.8 hectares, agricultural surface – 0.6 hectares, forest surface – 0.4 hectares, surface destined for any type of infrastructure – 0.2 hectares.

The role of the human component in the change of terrain stability is synthetically evaluated by using a series of indices (Pătroescu Maria et al., 2000; Bastian O., 2002). The assessment was conducted at the level of the administrative territorial units that are totally or partially included in the Bălăciţa Piedmont and concerned a period of 30 years (1977-2007).

Terrain observations have been constantly conducted in order to make clear or to provide new details that were not observable on the maps.

RESULTS AND DISCUSSIONS

Among the indicators that are relevant for the analysis of the environmental changes, the following were chosen for this research: the population density and the importance of infrastructural elements, the human stress through arable use, the landscape naturality index, and the environmental change index.

Population density and infrastructure

The transportation network, a requirement for the good functioning of any social-economic system, represents at the same time a footprint of the human pressure upon the environment and, under certain conditions, an element that influences the appearance and the evolution of geomorphologic processes (Nir Dov, 1983). The construction of roads required cut or fill operations on certain sectors, modified the flow regime of the rainwater on the slopes and the profile of the slopes. This communication network (Fig. 1) is mainly represented by two important railroad sections (Strehaia - Drobeta Turnu-Severin, Craiova – Segarcea) and a dense system of roads of European, national, county and communal importance, as well as the tracks with local use.

The damming of certain rivers is to be added as element of infrastructure and footprint of the human-induced transformations. This is the case of the Drincea, in the precincts of Rogova and Livezile settlements, the Rasnic, with its tributary, the Mereţel, near Cernateşti, Predeşti and, respectively, Brabova and Breasta settlements.

The average population density in the Bălăciţa Piedmont was 0.48 persons/hectare in 2007 (in permanent decrease since 1977, when it registered 0.61, then, in 1992 – 0.51 persons/hectare), reaching the minimum value of 0.19 persons/hectare in the commune of Prunişor and the maximum value of 1.92 persons/hectare at the level of Filiaşi town. Of the 55 administrative-territorial units (ATUs) of the Bălăciţa Piedmont, 39 register population densities below the average value. Thus, the value classes of interest are 0.56 - 0.75 persons/hectare (Vânju Mare, Pleniţa, Caraula, Argetoaia, Scaeşti, Coţofenii din Dos) and 0.76 - 1.10 persons/hectare (Breasta, Podari, Braloştiţa), which are characteristic for the units located at the border of the piedmont or near the urban settlements (Strehaia, Filiaşi and Craiova). During the 30 years interval under analysis, only five of the 55 ATUs registered a small increase of the population density (Filiaşi, Strehaia, Podari, Breasta, Braloştiţa). They are located along the eastern border of the Piedmont and attracted a higher number of persons (being towns or being located near Craiova).

In 2007, the part of the surfaces occupied by constructions and roads in the total administrative surface showed high values at the level of the following ATUs: Filiaşi, Podari and Izvoare (6.49 - 8.43 percent); Braloştiţa, Ţuglui, Giubega, Caraula, Vlădaia and Vânju Mare (5.16 - 6.48 percent). 4.65 percent of the total surface of the piedmont is occupied by roads and constructions, the minimum value (2.09 percent) being registered in Hinova ATU and the maximum (8.43 percent) in Podari ATU.

Through the load added by the constructions, numerous villages located on inclined surfaces break the balance of the slopes and lead to landslides; this occurs after a very important time interval, the reasons being diverse: a season with more important rains than usual, an earthquake etc. For example, in 1997, during the spring precipitations, in the settlement of Secu (Dolj County), located on a slope with 70 degrees inclination, an entire household was displaced because of the moisturizing of the clay strata on which the houses and other private constructions had been built and all constructions were destroyed.

Furthermore, the more accentuated building of households during the last century, as well as the maintenance of certain transportation lines required materials that were extracted from quarries and clay from the floodplains. As a consequence of these types of activities, new unbalances occurred, leading to landslides or water bogging.

The human stress through arable use

The human stress on the environment represents a synthetic indicator of its quality and of its degree of transformation following the human intervention (Goudie A. and Viles Heather A., 2003; Goudie A., 2006). Given the fact that within the case study area the rural space and the agricultural activities are dominant, it becomes necessary to conduct an analysis based on the interactions of these activities and of the various types of land use with the elements of the natural environment.

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The human stress on the environment is more accentuated as the above-mentioned activities attracted in the agricultural circuit wide surfaces on which the spontaneous vegetation was replaced by cultures (Dumitraşcu Monica, 2006). In order to understand the spatial dynamics and the tendencies of the terrains within the Bălăciţa Piedmont, the analysis concerned the situation registered in 2007, paralleled with the state of the affaires in 1977, 1992 and 2002 (Fig. 2).

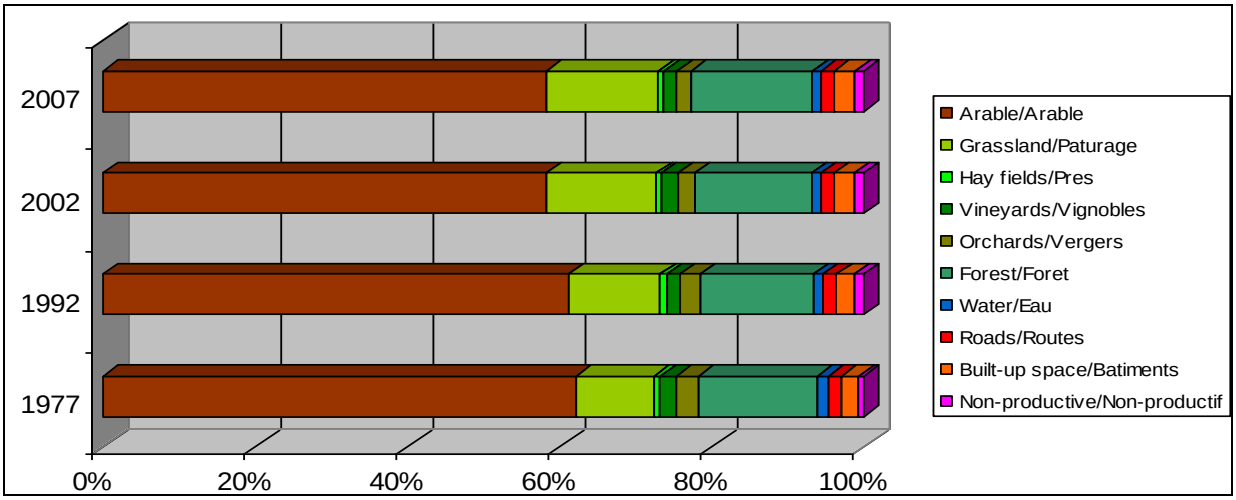

Fig. 2 Dynamics of land use in the Bălăciţa Piedmont (1977 - 2007)

Firstly, in the agricultural domain there is to be noticed the significant decrease of the surfaces under annual or perennial cultures in the favour of the grassland. Thus, if 230,978 hectares were used as arable land, 7,875 hectares as vineyards, and 10,575 as orchards in 1977, during the last year of analysis these land use categories diminished their surfaces to 210,871 hectares, 6,215 hectares, and 6,598 hectares respectively.

During the same interval, the grassland surface showed an accentuated increase from 37,856 hectares in 1977, to 53,215 hectares in 2007. One important explanation of this situation lays in the transformations appeared at the level of the ownership after 1989, which was accompanied by maintenance difficulties, high production costs and problematic marketing, especially for the small farmers. On the other hand, the terrains assimilated to the grassland are often simply represented by surfaces left uncultivated.

Regarding the non-agricultural domain, there is to be noticed the reduction of the surfaces occupied by forest (58,442 hectares in 1977, 54,753 hectares in 1992, when incontrollable clearings occurred, and 57,652 in 2007), by water bodies (4,800 hectares in 1977, 4,566 hectares in 1992 and 4,325 hectares in 2007), while the surfaces occupied by civil constructions and industrial or trade units displayed a positive trend (8,323 hectares in 1977, 8,227 hectares in 1992 and 9,876 ha in 2007).

The presented state of affairs needs to be analysed in the framework of a significant population drop within the case study area (222,702 persons in 1977, 189,268 in 1992, and 163,273 in 2007). Thus, despite the diminishing surfaces occupied by various agricultural crops, there can be nevertheless noticed an increase of the human stress in the area.

The human stress through arable use represents the arable surfaces reported to the number of inhabitants, being expressed in hectares/inhabitants and it was applied by FAO. In 2007, the index values calculated for the Bălăciţa Piedmont (Fig. 3) vary between 2.7 - 3.7 hectares/inhabitant – unbalanced landscape and 0.3-0.75 hectares/inhabitant – slightly affected landscape, the minimum value (0.28 hectares/inhabitant) being registered at the level of Strehaia town, while the maximum was reached in Vlădaia ATU (3.72 hectares/inhabitant). The highest values, comprised between 2.66 and 3.72 hectares/inhabitant, characterise 13 percent of the ATUs in the Piedmont. Units such as Poiana Mare, Padina Mare, Bâcleş, Vlădaia, Gogoşu, Brabova and Vela are included in this category, being located in the central part of the case-study area. The moderately high values of the 2.01 – 2.65 hectares/inhabitant class characterise 16 percent of the ATUs, which are more disseminated but can be still located in the central-southern part of the Piedmont (Livezile, Corlăţel, Bălăciţa, Seaca de Pădure, Orodel, Terpeziţa, Sălcuţa and Giubega communes). The ATUs located in the northern, north-eastern and eastern extremities of the piedmont show low values of this index, comprised between 0.28 and 1.20 hectares/inhabitant.

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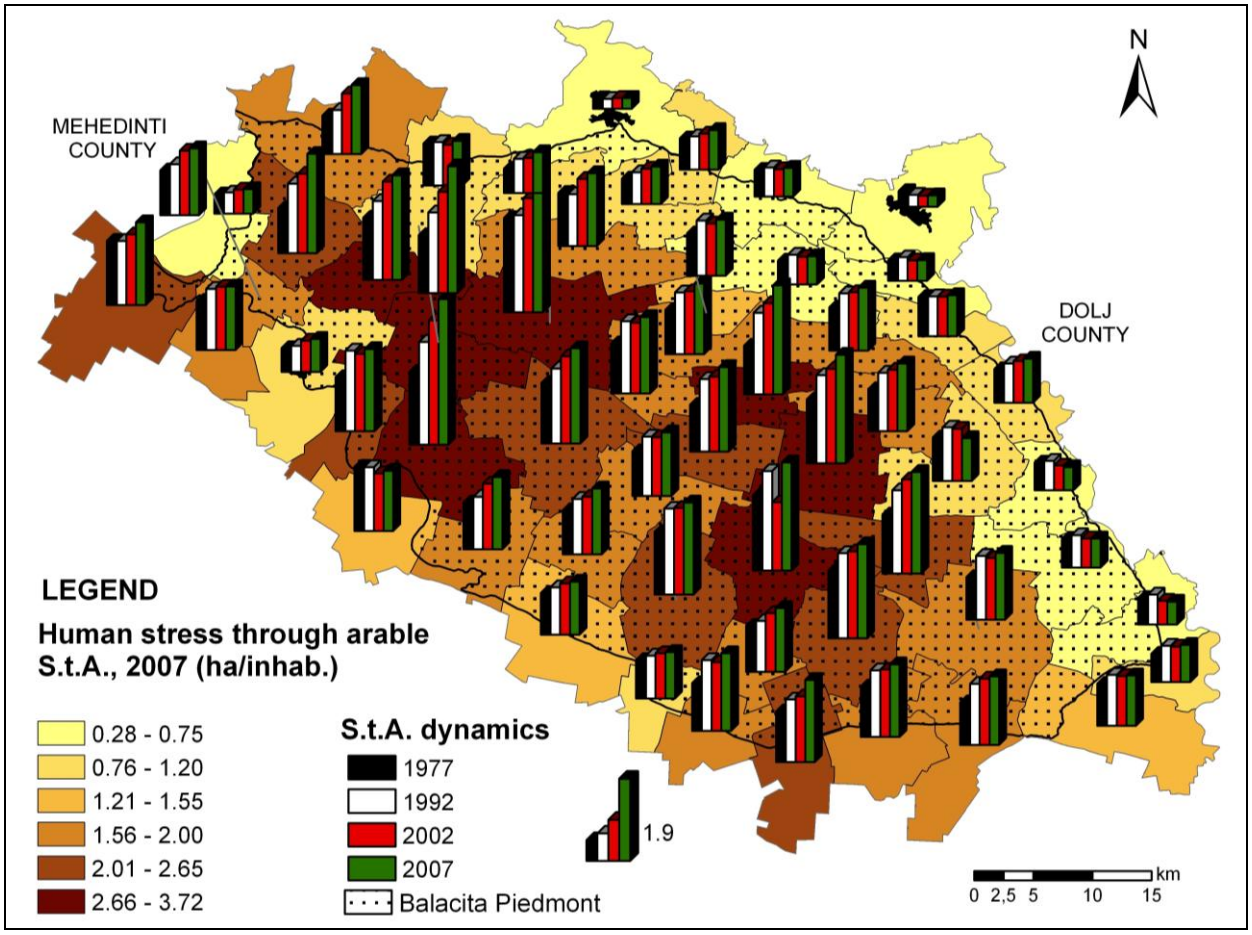

Fig. 3 The Bălăciţa Piedmont. Human stress through arable use

During the 1997 – 2007 interval, most of the ATUs in the Bălăciţa Piedmont undergone ascendant dynamics of the human stress through arable use index. The comparative analysis of the index values in the four years under study (1977, 1992, 2002, 2007) shows a permanent increase in 91 percent of the ATUs under study. More significant augmentations were registered at the level of the following communes: Livezile, Poroina Mare, Padina Mare, Dumbrava de Jos, Bâcleş, Vlădaia, Bălăciţa, Greceşti, Botoşeşti-Paia, Verbiţa, Seaca de Pădure, Gogoşu, Cernăteşti, Sopot, Brabova, Vârtop, Giubega, Sălcuţa, Terpeziţa, and Radovan. Only five ATUs (the remaining 9 percent) displayed a decreased value of this index over the 30 years. The position (near Craiova) or the status (town) of such units as Podari, Breasta Filiaşi explains the lower value registered in 2007 as compared to 1977.

The landscape naturality index

It is calculated as the ratio between the forest fund surface and the total surface and it is expressed in percent. The lowest values of the index are included in the class 0 - 3.5 percent - landscape with almost entirely affected balance, while the highest values, 30 - 45% - underline the landscape slightly affected by the human intervention, in which the forest fund shows important values. In 2007, the minimum value was reached in Caraula ATU (0.08%), while the maximum was registered in Perişor (44.08%).

The analysis of the distribution of the landscape naturality index in the Bălăciţa Piedmont in 2007 (Fig. 4) highlights three areas with poor forest surfaces (corresponding to the values comprised between 0 and 3.5%), mainly located in the central and central-southern parts of the piedmont: 1. Greceşti, Bâcleş, Bălăciţa, Vlădaia, and Oprişor; 2. Predeşti, Brabova; 3. Orodel, Caraula, and Giubega.

The variation of the index on a 30 years interval (1977-2007) underlines the following aspects: only two out of the 55 ATUs of the Piedmont (Braloştiţa and Coţofenii din Dos) registered a decrease of the index value starting with 2002, while other two units (Dumbrava de Jos and Brezniţa-Motru) undergone forest surfaces reduction in 2007, as compared to the previous period; in 5 percent of the ATUs (Bâcleş, Padina Mare and Poroina Mare), the part of the forest surfaces increased between 2002 and 2007, after the decline registered in the 1977 - 2002

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interval; ten percent of the ATUs under study (Hinova, Rogova, Devesel, Punghina, Radovan, and Greci – mostly located near the border of the case-study area) undergone permanent increase of the index value, reaching the highest value in 2007.

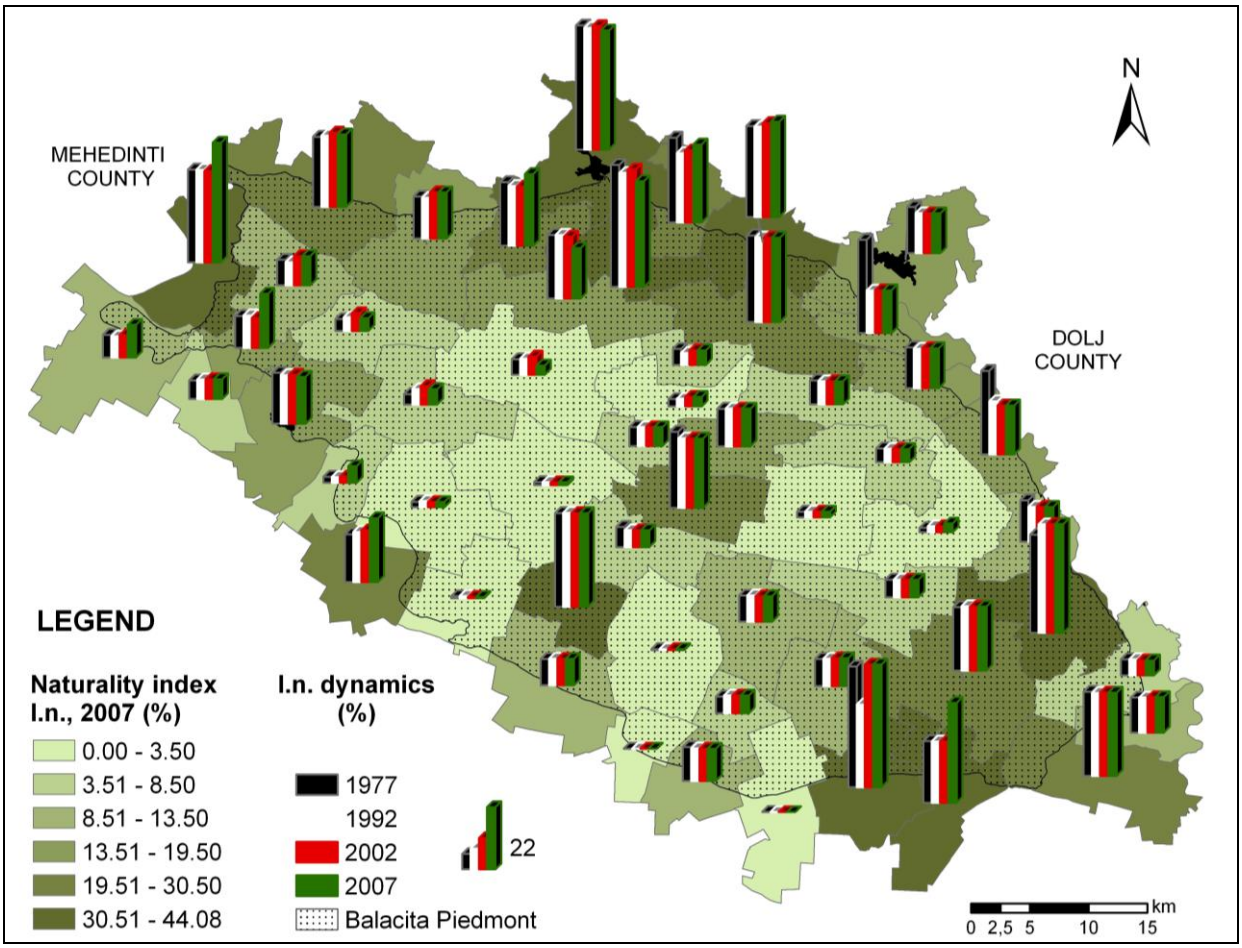

Fig. 4 Indicators of the human pressure on the environment in the Bălăciţa Piedmont. Landscape naturality index

The environmental change index

It was calculated as ratio between the sum of the surfaces occupied by forests and grassland, on the one hand, and the built-up surface, on the other. This index was used by Maruszczak in Poland, in 1988 and by Pietrzak, in 1998, for the assessment of the human impact on the Sub-Carpathian landscape in Poland. In Romania, it was applied by Manea (2001), in the assessment of the human-induced transformation of the landscape in the *Portile de Fier* Nature Park and by Manea and Patru (2004), in the evaluation of the anthropised landscape on the Buzău River valley, as well as by Dumitraşcu Monica (2006), in the assessment of the human impact on the landscape of the Oltenian Plain.

The values shown by this index at the level of the Bălăciţa Piedmont (Fig. 5) varied in 2007 between 0 - 4.3 – landscape with almost entirely affected balance and 25 - 39 – slightly affected landscape. The minimum value (0.53) was registered in Caraula ATU, while the maximum value (38.80) – at the level of Hinova unit. Sixteen percent of the ATUs under study (i.e. Vlădaia, Pleniţa, Caraula, Izvoare, Vârtop, Giubega, Vânjuleţ ATUs, grouped in the southern and south-western parts of the piedmont, as well as Podari and Ţuglui units, located in the eastern part) registered the lowest values of the environmental change index in 2007 (up to 4.3).

The northern, north-eastern and eastern extreme parts of the piedmont are characterised by significant surfaces occupied by forest and grassland, as compared to those occupied by constructions, the values of the index being comprised between 12.28 and 38.83. In the central part of the Bălăciţa Piedmont, the dominant values of the index correspond to the class 8.23-12.27 (ca 25 percent of the total number of units) and they were registered in Rogova, Poroina Mare, Padina Mare, Bâcleş, Secu, Bălăciţa, Botoşeşti-Paia, Braloştiţa, Sopot, Breasta, Terpeziţa and Vela ATUs.

The analysis of the environmental change index dynamics at commune level in 1977, 1992, 2002, and 2007 led to some important observations. Thus, in 16

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percent of the settlements (Argetoaia, Butoieşti, Braloştiţa, Coţofenii din Dos, Calopăr, Sălcuţa, Verbiţa, Sopot, and Vlădaia ATUs), the index registered a significant decrease between 1992 and 2002 (with higher values during the 1992 – 1997 interval and lower ones after 2002). Seven percent of the total number of units (Hinova, Tâmna, Rogova – located in northwest - and Radovan – located in southeast), displayed an ascendant trend in the values of the index between 1997 and 2007. The index values characteristic to the other ATUs presented little variation during the time interval under analysis (1977 - 2007), certain changes of the environmental change index being noticeable at the level of the year 1992.

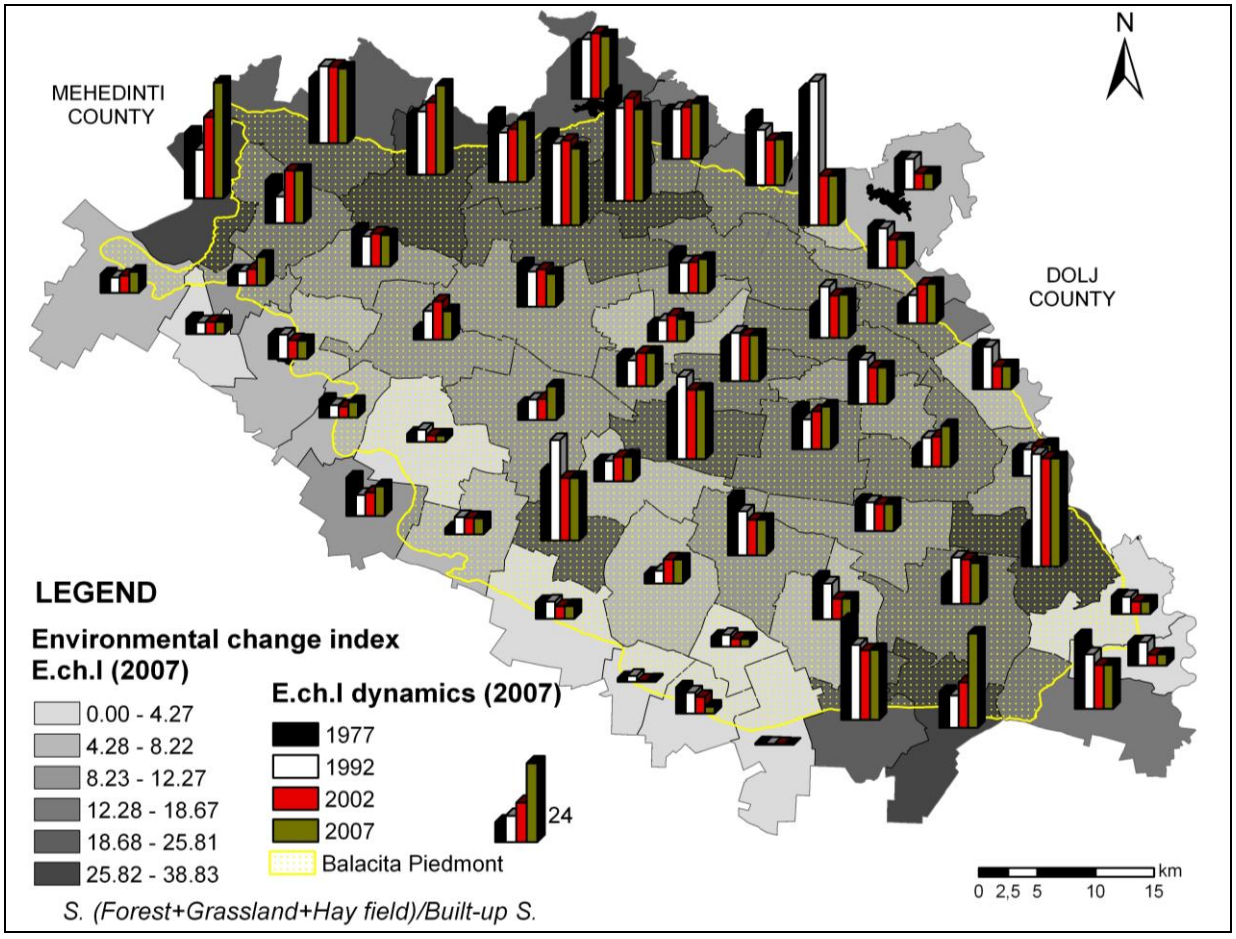

Fig. 5 Indicators of the human pressure on the environment in the Bălăciţa Piedmont. Environmental change index

CONCLUSIONS

The areas affected by landslides, located in the eastern extremity of the Bălăciţa Piedmont, correspond to the ATUs with high population density (0.56 – 1.10 persons/hectare).

The collapse processes, which are dominant in the eastern and western extreme parts of the piedmont, are correlated with the altitudinal differences and with the characteristics of the local natural borders of the unit, respectively the Jiu and the Danube.

The comparative analysis of the surfaces affected by the two major geomorphologic processes in the northern half of the case-study area (hydric processes), respectively the southern half (piping and compaction) with the statistical analysis of the human pressure indices (naturality index, environmental change index and human stress through arable use) brings to the following conclusions:

a. The piping and compaction processes are closely connected to the naturality index (the values comprised between 0 and 3.5%, in 2007) and show high frequency in the three areas characterised by scarce forest fund, mainly located in the central and central-southern part of the piedmont. Secondly, the manifestation of the two types of geomorphologic processes within the piedmont can be correlated with the values of the environmental change index, respectively with those comprised between 0 and 4.3 (characteristic to the ATUs located in the southern and southwester part of the piedmont and to Podari commune, located in the east).

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b. The hydric processes are predominant in the northern, north-eastern and eastern areas of the Bălăciţa Piedmont; on the one hand, these processes overlap the areas where the environmental change index shows higher values of the surfaces occupied by forest and grassland as compared to those occupied by constructions (values comprised between 12.28 and 38.83, in 2007) and, on the other hand, they overlap ATUs with low values of the human stress through arable use (values comprised between 0.28 and 1.20 hectares/inhabitant).

To conclude, one of the key-elements for the sustainable development of the region is raising the awareness of the community concerning its impact on the environment in general and its relation with the geomorphologic phenomena of risk in particular; the teaching of methods and examples of good practice for the prevention of such phenomena and for the limitation of their effects is also of great importance (Bălteanu D., 1994). Integrating the results of the geomorphologic research in the environmental politics and their application would be substantially facilitated, because, for instance, the affected society can understand more easily the impact of the land use change on their degradation and on the appearance of the hazardous geomorphologic phenomena (Kimberly M. Mattson and Paul L. Angermeier, 2007).

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