

Land Use in the Sub-Carpathian Area of the Cricovul Sărat River Basin. Environmental Impact Assessment

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ABSTRACT

The paper aims at analyzing the state of the environment in the administrative territorial units overlapping the Sub-Carpathian region of the Cricovul Sărat watershed. The study area, which lies in the Curvature Sub-Carpathians, covers 595 sq km and includes 19 administrative territorial units, out of which the Cislău commune belongs to Buzău County whereas the other 18 are administratively included within Prahova County borders. In order to accomplish our goal, we analyzed the dynamics of agricultural land use between 1990 and 2012. We analysed the evolution of the entire agricultural area, but we also took into account arable land, pastures, vineyards and orchards. We found that agricultural land and the areas covered by vineyards and orchards decreased, while the pastures extended significantly. Another research direction was the assessment of environmental condition through a number of indices, such as: the human pressure index, the naturality index, and the environmental transformation index. The data employed was provided by the National Institute of Statistics. The human pressure index mirrored by the use of agricultural land shows a moderately balanced and a slightly unbalanced landscape for the entire territory. On the whole, the naturalness index points at a landscape with a less affected ecological balance. The moderate anthropogenic influence over the entire region is shown by the environmental transformation index.

1. INTRODUCTION

The aim of the study is to perform a diachronic analysis (between 1990 and 2012) of the agricultural land (arable land, pastures and hayfields, vineyards, orchards) included in the territorial administrative units of the Sub-Carpathian Basin of the Cricovul Sărat River. The rural landscape has suffered changes over time through the intensification of agricultural and forest exploitation activities, with repercussion on the environment [1]. Thus, to reveal the ecological status of the territory studied, a number of indicators were analyzed: human pressure indexes - through human population dynamics (population density), the human pressure through the use and occupation of the agricultural land, the naturality index, the

environmental transformation index. These indicators are called elementary indicators of the landscape evaluation [2]. The human pressure expressed by the land use and the degree of occupation of agricultural lands was computed either at national level [3] or separately, for various regions of Romania: the Romanian Plain at large [4], the Mostiștea Plain [5], the Oltenia Plain [6], the Târgoviște Plain [7]; the Sub-Carpathians between the Râmnicu Sărat and Buzău rivers [8], [9], the Oltenia Sub-Carpathians [10]; the Getic Piedmont [11]; the Iron Gates Natural Park [12], the Bran-Rucăr-Dragoslavele Corridor [2], the Almăj Land [1]. Likewise, the naturalness index was computed for plain areas [6], hills [10], [11], [13], and highlands [12], [2], [1], etc. The last analyzed, namely the environmental transformation index, mirrors the

relationship between the natural and altered areas. This was used for the first time in order to analyze the landscape situated at the foot of the Polish Carpathians [14], [15]. In Romania, it was employed for assessing the quality of the landscape in the Oltenia Plain [6], the Bâsca Chiojdului watershed [13], the Iron Gates Natural Park [12], the Rucăr-Bran-Dragoslavele Corridor [2], the Almăj Land [1], etc.

1.1. Study area

The territory analyzed is located in two subunits (Sub-Carpathians of Buzău and Prahova) of the Sub-Carpathians of Curvature in the area of the basin of the Cricovul Sărat River (fig. 1).

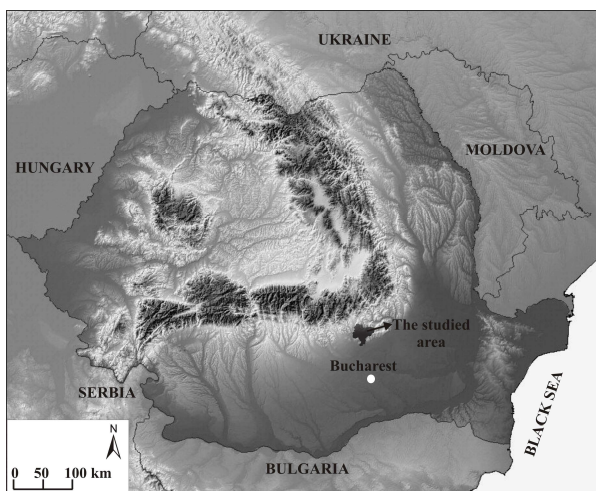


Fig. 1. Geographical position of the study area.

Cricovul Sărat basin is part of the Ialomița river basin. As altitude is concerned, the territory runs from approx. 120 m to limit the Romanian Plain and 717 m, the Salcia Hill.

2. THEORY AND METHODOLOGY

Human settlement is one of the essential realities that dominate the space [16] and ensure the conditions of transformation of the territory. The territory occupied by the human settlements is individualized by the natural components and by their potential, but also by economic and social factors [17]. The relationships between the natural components achieved multiple changes triggered by the development of the settlements network. In general, the Sub-Carpathians have provided good conditions for the establishment and development of the human habitat [19]. This is also valid for the geographic area under study. Thus, in the Sub-Carpathian area of the Cricovul Sărat River, the density of villages reaches about 16 villages/100 km², with approx. 38% above the average value of the rural settlements in the whole Sub-Carpathian region – 11.56 villages/100 km² [18].

The studied area includes 19 territorial administrative units, 18 communes (Apostolache, Aricești Zeletin, Bălțești, Cărbunești, Chiojdeanca, Cislău, Gornet, Gornet-Cricov, Iordăcheanu, Lapoș, Păcureți, Podenii Noi, Predeal-Sărari, Salcia, Sângeru, Surani, Șoimari, Tătaru), which consist of 79 villages and Urlați city (with 16 rural components).

Urlați city occupies a peripheral position being located in the southern part, at the contact with the Istriței Plain (part of the Romanian Plain). That is why we can say that this space is predominantly rural. We believe that an important role in this situation had the fragmentation of the relief and distribution mode of the valleys network. Thus, both Cricovul Sărat River and its tributaries (Lapoș, Mireș, Salcia, Vărbila, Chiojdeanca) have their springs in the Sub-Carpathian hills, forming a dendritic drainage systems. This did not allow for the appearance of a trans-Carpathian circulation corridor and the appearance of polarizing centres was limited. In the investigated territory, the European roads are missing together with the national roads, except for a short section (of 7.5 km) in the Northeast (DN 10 – section Viperești – Cislău – Gura Bâscei – Poienile).

The natural conditions are favourable to the development of natural deciduous forests. Sessile oak (associated with hornbeam, elm, linden, oak) that predominate in the South and beach mostly in the North [19]. Over time these forests were deforested. At present (2012), forests occupy just 32.2% of the total studied area. Deforested lands were occupied over time by human settlements, roads and agricultural lands (which are prevalent – 57% in 2012). Besides, agriculture is considered one of the most important forms of human pressure on biodiversity [20] and the most significant cause for land use alteration [21].

That is why we proposed the diachronic analysis of agricultural land. Also, to assess of the environmental impact due to changing land use, we calculated a number of elementary indicators: the human pressure indexes (density of population, human pressure through the use of agricultural land), the naturality index, the environmental transformation index. They are known as indicators of the quality (sustainability) of the landscape [2]. The human pressure index on agricultural lands reveals the effective use of these lands, by dividing the agricultural area (overall or by land use types) to the number of inhabitants. The results obtained were compared to the limits prescribed by FAO [12], [6], [9], [7], [2], [1], for maintaining an ecological balance. We also made comparisons with the present situation at national level.

The forest is an environmental balance factor, as forested areas are generally considered natural or sub-natural areas [22], [23]. This is why, even though it may seem a simplistic assessment, out of the lands that support the development of forest ecosystems from the ecological standpoint, the share of forested areas may

suggest the naturalness of the landscape [12]. Also, deforestation is a direct cause of biodiversity loss [21]. The value of this index was compared with the value computed at national level. For a better judgment of the

anthropogenic impact, we also computed the environmental transformation index. Accurate results can be obtained only if we pay particular attention to the extension of the natural and altered landscapes [2].

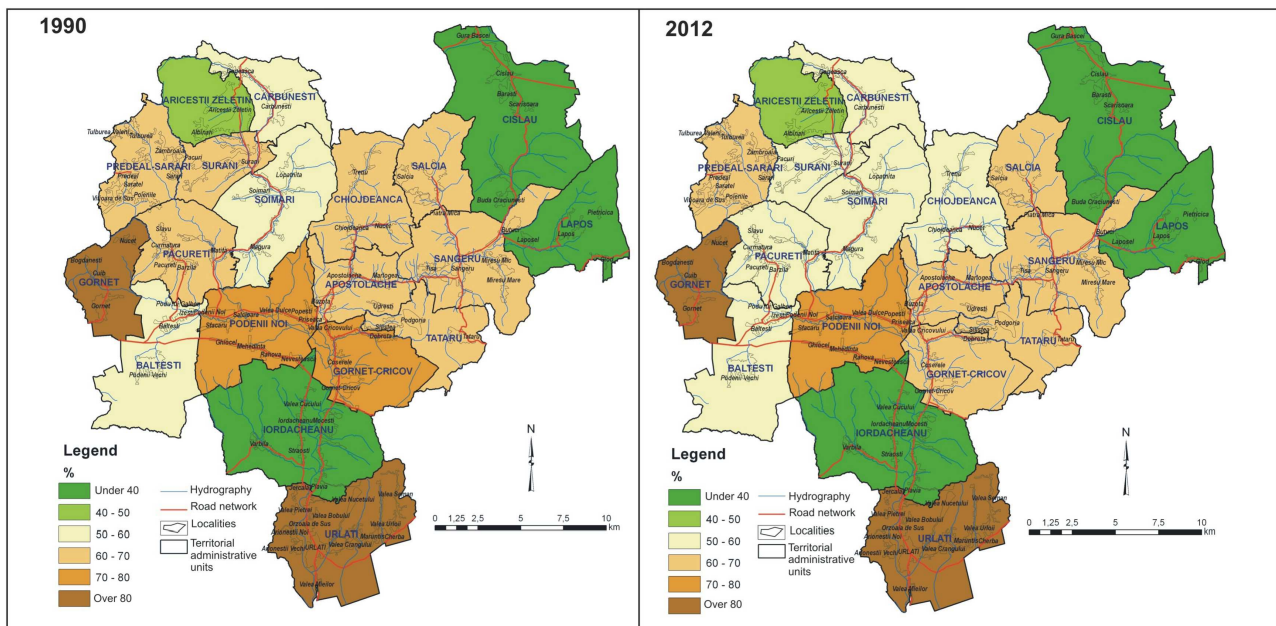


Fig. 2. The share of total agricultural land in the administrative territorial units (in 1990 and 2012).

The reports were made at the level of the territorial administrative units; therefore, the studied area (595 km²) exceeds the area of the hydrological basin of the river Cricovul Sărat by approximately 15%. The data used are taken from the National Institute of Statistics [24]. With the exception of the commune Cislău (Buzău), other localities belong to Prahova County. The analysis was performed both for the entire territory and at the level of administrative territorial units. In order to put the data into perspective, a series of maps were constructed using the program ArcGis 9.3.

3. RESULTS AND DISCUSSION

3.1. Agricultural land use analysis

Of all territorial administrative units, the largest areas are occupied by the communes of Cislău (10.3% of the total) and Iordăcheanu (9.2%) followed by Urlați city (7.4%). The smallest surface is occupied by Surani commune (2.7%). Small areas are also registered by the communes of Apostolache, Aricești-Zeletin, Cărbunești, Gornet, Salcia, Tătaru, each with less than 4% of the total [25].

In 1990, the total agricultural area was of 58.6% of the area analyzed. In 2012, the percentage fell to 57.00%. Currently (2012), the highest percentage of agricultural land is recorded (fig. 2) in the communes of Gornet (85.0%), Podenii Noi (73.3%) and Urlați city (83.2%) and the lowest (below 40%) in the communes of Cislău (34.3%), Iordăcheanu (38.8%) and Lapoș

(38.9%). As a share of the total administrative territorial units, the agricultural area decreased by 1.6% between 1990 and 2012. The total area decreased by 2.6%. The localities of Urlați, Gornet and Podenii Noi participate with about a quarter to the total agricultural land in the entire area under analysis.

In 1990, the *arable land* occupied 26.4% of the total agricultural area of the Sub-Carpathian Basin of the river Cricovul Sărat. In 2012 it increased to 28.1%. At the level of administrative territorial units (2012), the largest arable land areas (over 40%) are located in the municipalities of Podenii Noi (47.1%), Bălțești (45.9%), Iordăcheanu (45.6%), Gornet (41.1%). However, Chiojdeanca has the lowest percentage of arable land (5.2%) (fig. 3). Between 1990 and 2012, arable land increased slightly (by 1.7%) compared to the total agricultural land. For the total arable area, the increase was of 6.9%. The communes with the highest percentage of arable land are located in the Podeni Depression with altitudes below 200 m [25].

In 1990, *pastures and hayfields* occupied 54.1% of the total agricultural area and in 2012 their share increased to 62.3%. In 2012, the maximum value is found in the Păcureți commune (fig. 4), meadows occupying 84.4% of total agricultural land. The next two places are occupied by communes Chiojdeanca (84.2%) and Surani (83.6%). On the opposite site is the city of Urlați with 31.1% pastures and hayfields. Between 1990 and 2012, the share of pastures and hayfields in the total agricultural land increased by 8.2%. Total area has increased with 10.8%. With the exception of two

communes (Gornet and Gornet-Cricov), meadows area increased in all administrative territorial units. The characteristics of the Sub-Carpathian natural environment, favoured the predominance of meadows areas in the structure of agricultural areas. Overall,

pastures and hayfields hold more than half of the agricultural land of each community.

Exceptions make the communes of Bălțești (43.5%) Podenii Noi (47.1%) and Gornet (49.4%) and Urlați city (31.1%).

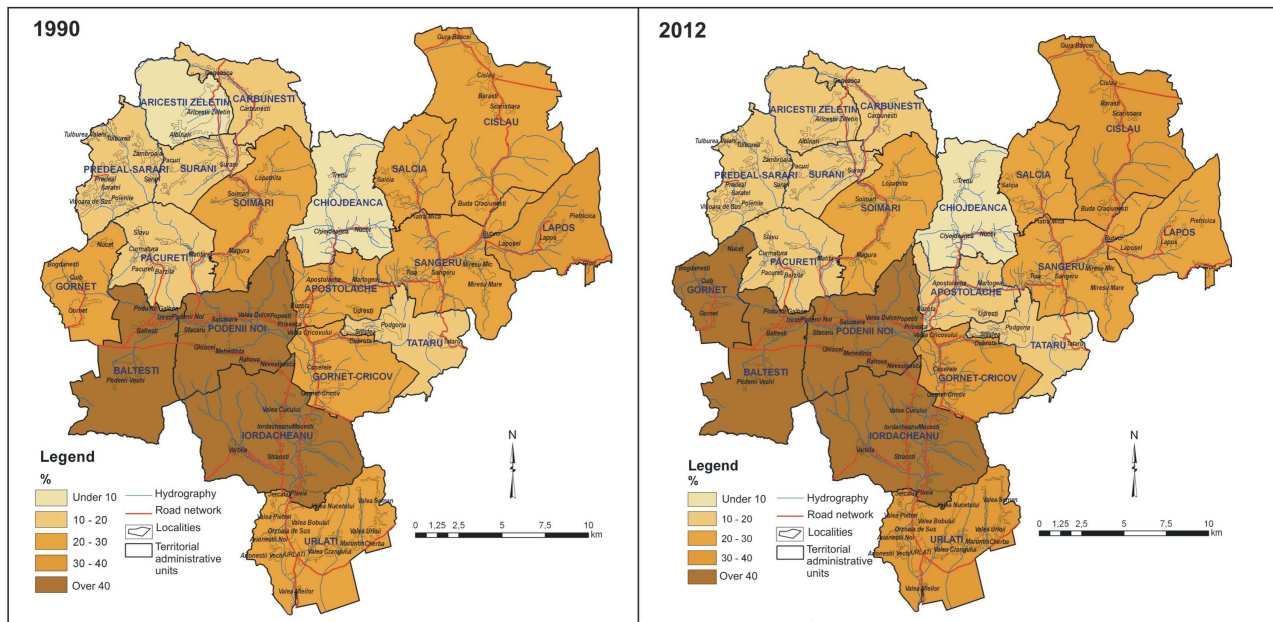


Fig. 3. The share of arable land in the total agricultural land (in 1990 and 2012).

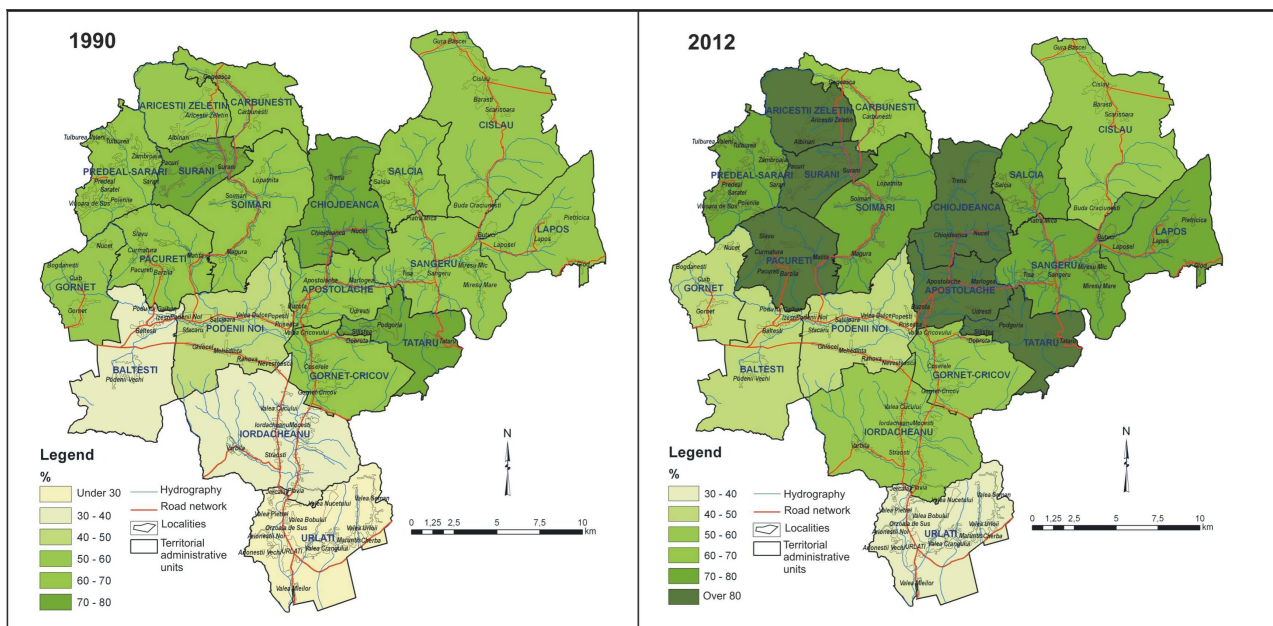


Fig. 4. The share of pasture and hayfields in the total agricultural land (in 1990 and 2012).

In 1990, *vineyards areas* were of 8.3% of total agricultural land throughout the entire studied territory. The share declined steadily to 5% until 2012. The city of Urlați registers the highest share of vineyards (fig. 5) although there was also a decrease of 13.8%.

The *orchard areas* also have decreased in the last two decades (12.3% in 1990, 4.5% in 2012. In 2012, Cărbunești commune (fig. 6), in the north basin of

Cricovul Sărat river, in the highest Carpathian hills area, registered the most extensive orchards (19.3% of its agricultural land), about 1/7 of the total orchard area of the Sub-Carpathian basin of the Cricovul Sărat river. In 1990, the commune Aricești-Zeletin occupied the first place, with 38.1%.

The diachronic analysis shows a constant decrease in the area occupied by vineyards (3.3%) and

orchards (7.8%) in the total agricultural land in parallel with the expansion of meadows areas. Thus, in 2012, the areas occupied by vineyards accounted for only 60.4% compared to 1990 (decrease by 39.6%). Moreover, the areas with fruit trees represented only 36.4% compared to 1990 (decrease by 63.6%). The city of Urlați (2012) holds 72.7% of all existing vineyards throughout the territory studied, situation explained by

the inclusion within its administrative limits of the sectors of Ceptura and Bucovel hills at glaciis contact which makes the connection with the Istrița Plain.

Thus, an area traditionally included in the famous vineyard Dealul Mare. The most significant reduction of orchard areas was in the village of Aricești-Zeletin (orchard area in 2012 representing only 18.4% of that of 1990).

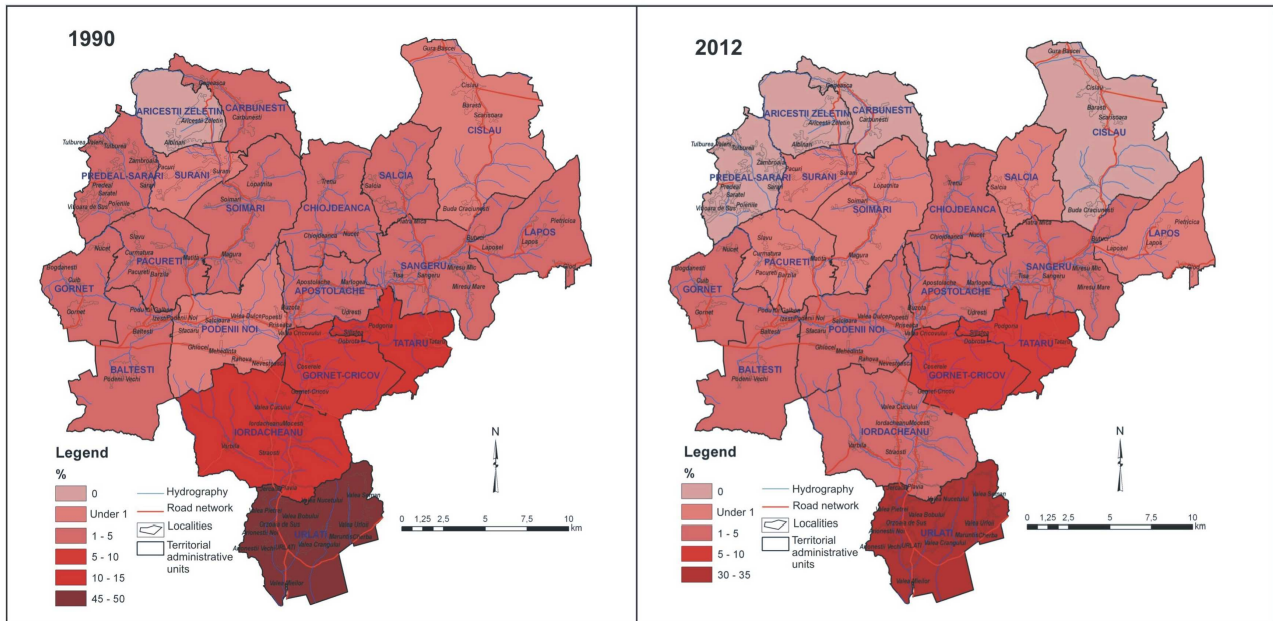


Fig. 5. The share of vineyards in the total agricultural land (in 1990 and 2012).

3.2. Analysis of the environment quality indicators

Human pressure on the environment can be appreciated, as we have shown, through a number of indicators: population density, human pressure through the use of agricultural land, the naturality index, the environmental transformation index. The pressure implied by human population dynamics [13] is reflected by population density. In the period 1990-2012, the general trend was the decrease of population. In the entire basin, the number of inhabitants decreased by 5,910. In the majority of the territorial administrative units the number of inhabitants diminished. Exceptions are the communes of Bălțești (+ 3.4%), Podenii Noi (+ 2.1%) and Iordăcheanu (+ 0.7%), that recorded a slight increase. The largest declines in the number of inhabitants (with over 25%) were recorded in the communes: Tătaru (- 34.5%), Lapoș (- 32.5%), Salcia (- 31.5%), Aricești-Zeletin (- 28.8%) and Apostolache (- 26.3%). One of the causes of population decline is the decrease of the birth rate.

Therefore, *population density* has decreased overall. In the entire investigated territory it decreased from 113.0 inhabitants/km² to 103.1 inhabitants/km². At the national level in 1990 the density was of 97.3 inhabitants/km² and of 89.4 inhabitants/km² in 2012.

At Prahova county level the density was of 186.7 inhabitants/km² in 1990 and of 170.7 inhabitants/km² in 2012. At Buzău county level the density was of 85.4 inhabitants/km² in 1990 and of 77.7 inhabitants/km² in 2012. The commune of Cislău, the only one of the researched region which is located in Buzău County, had a density close to that of this county (82.3 inhabitants/km² in 1990 and 81.5 inhabitants/km² in 2012). The communes of Bălțești, Podenii Noi and Iordăcheanu recorded a slight increase.

The highest population density was recorded in the Urlați city (277.4 inhabitants/km² in 1990 and 257.9 inhabitants/km² in 2012). The lowest population density was recorded in the commune of Lapoș (64.1 inhabitants/km² in 1990 and 43.3 inhabitants/km² in 2012). Over 100 inhabitants/km² densities were recorded in 1990 in the communes: Gornet (156.9), Sângeru (141.5), Apostolache (134.7), Surani (132.2), Podenii Noi (127.1), Predeal-Sărari (112.9), Gornet-Cricov (104.2). Over 100 inhabitants/km² densities were recorded in 2012 in the communes: Gornet (141.9), Sângeru (137.9), Podenii Noi (129.7), Surani (111.9), Apostolache (109.6), Bălțești (103.0). Anyway, according to Trebici (1979) a density of 2-3 inhabitants/km² or above this value is a visible sign of human pressure on the environment. Human pressure through the use and occupancy of the land represents a set of indicators. Selecting classes for

use and occupancy of the land is made according to the studied area [2].

The most common of these is the human pressure index through the use of agricultural land.

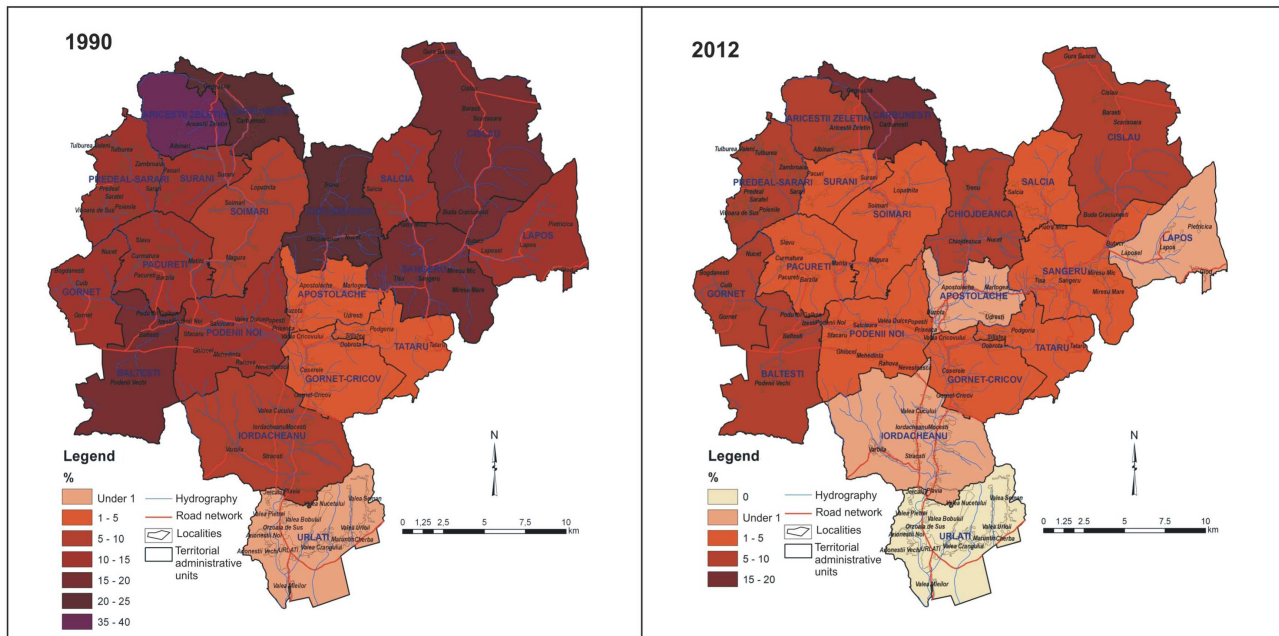


Fig. 6. The share of orchards in the total agricultural land (in 1990 and 2012).

Human pressure on the environment through the use of agricultural land rises with the share of agricultural area per inhabitant [9]. Hence, in other words, if a large number of inhabitants could be supported through a low agricultural area it would look efficient use of land. The formula used is: $P_c = S_c/N$. P_c (Pressure class) is human pressure through a certain class of use and occupation of land. S_c (Surface class) is the area occupied by the selected class; it is measured in hectares. N is the number of inhabitants. Pătru-Stupariu (2011) proposes four types of territories depending on the values of the indicator of human pressure through the use of agricultural land in accordance with the limits prescribed by FAO [2]. According to this classification, for the different administrative territorial units from the Sub-Carpathian area of the Cricovul Sărat basin, we identified the following types of agricultural (rural) landscapes (fig. 7):

- slightly balanced natural components (below 0.40);
- moderately balanced and poorly unbalanced (0.41 to 1);
- strongly unbalanced (1.1-2.0).

The human pressure index through the use of agricultural land shows a moderately balanced and poorly unbalanced landscape through the values of 0.52 (1990) and 0.55 (2012) for the whole territory. The values for the two years remain similar, because although agricultural area decreased the number of inhabitants (7.8%) decreased as well. These values attest a better balance than the one existing at the national level (0.64 in 1990 and 0.69 in 2012). We

believe that the results obtained need to be corroborated depending on how to use agricultural land. So, use as arable land, as vineyards and orchards (the intensive) implies a greater human impact. Pastures and hayfields, even if they are deforestation result, can be considered as ecosystems with a greater degree of naturalness. Traditional orchards (with rows of trees among meadows) also can go into the same category.

For example, the commune of Tătaru, a strongly unbalanced rural landscape, in 2012 has recorded values of 1.33 (the highest value of all administrative territorial units). But, in this commune, in 2012 the share of pastures and hayfields is 80.1%. A different example is that of the Urlați city. Here in 2012 the human pressure by the use of agricultural land is of 0.32 (the lowest value of all administrative territorial units). But about 68.9% (34.8% arable land and 34.1% vineyards) is intensely human modified agricultural land.

To better highlight the issue of human pressure by the use of agricultural land we also calculated the following indicators: human pressure through the use of arable land, human pressure through the use of pastures and hayfields, human pressure through the use of vineyards, human pressure through the use of orchards. The calculation of these indicators (with the exception of human pressure through the use of arable land) was made for the whole studied area. In parallel, for comparison we obtained the national values. For human pressure by the use of arable land we obtained the following values: 0.13 in 1990 (0.41 for Romania) and 0.16 in 2012 (0.44 for Romania).

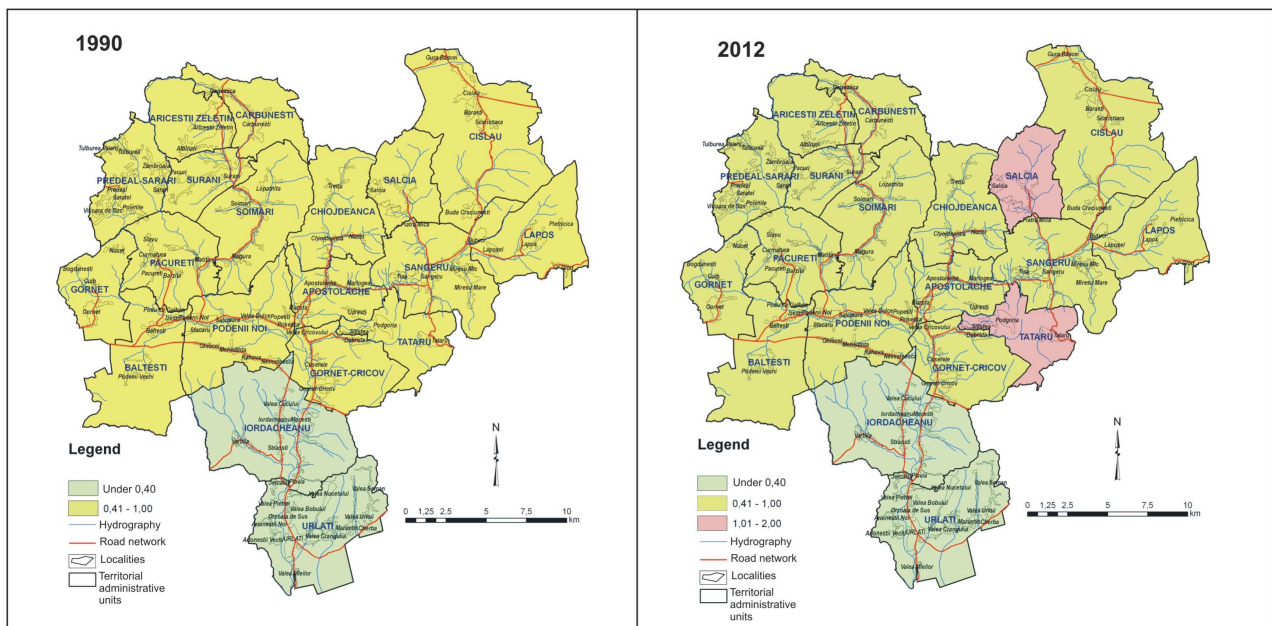


Fig. 7. The human pressure index through the use of agricultural land (in 1990 and 2012).

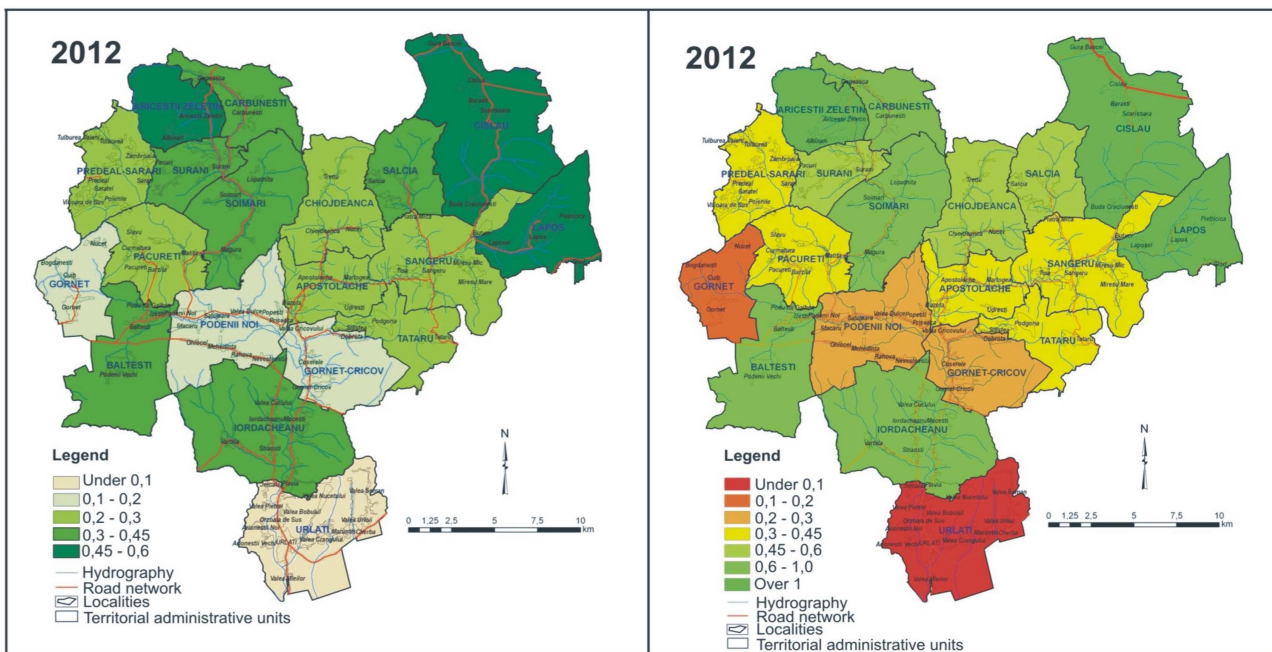


Fig. 8. The naturality index (left) and the environmental transformation index (right) in 2012.

The values obtained at the level of the territorial-administrative units range from 0.04 to 0.28. The lowest values are specific for the settlements lying in the north (Surani, 0.04 in both years; Chiojdeanca, 0.04 in 1990 and 0.05 in 2012; Aricești-Zeletin, 0.04 in 1990 and 0.07 in 2012; Cărbunești, 0.06 in 1990 and 0.07 in 2012), where elevation and relief dissection values are higher. The highest values are especially related to the settlements located in the Podeni Depression, which offers optimum conditions for the expansion of arable lands (Podenii Noi, 0.28 in 1990

and 0.27 in 2012; Bălțești, 0.24 in 1990 and 0.25 in 2012).

Sometimes, however, the settlements with lower shares of arable land in comparison with those mentioned above record high values of the human pressure index mirrored by arable land use. It is the case of Salcia village, which in 2012 recorded a value of 0.28 due to the sharp decrease (by 31.5%) in the number of inhabitants. Yet, one can note that both at the level of the entire region and at the level of the territorial-administrative units, the resulted values are

below the limit set by FAO and considered optimal for the preservation of ecological balance [12], [6], [9], [7].

For human pressure through the use of pastures and hayfields we obtained: 0.28 in 1990 (0.20 for Romania) and 0.34 in 2012 (0.23 for Romania). For human pressure through the use of vineyards we obtained: 0.04 in 1990 and 0.03 in 2012 (0.01 for Romania in the both years). For human pressure through the use of orchards we obtained: 0.06 in 1990 and 0.02 in 2012 (0.01 for Romania in the both years). So, on the whole, in the Sub-Carpathian area of the Cricovul Sărat basin, human pressure through the use of pastures and hayfields is the most representative.

The naturality index (NI) is defined as the ratio between the area occupied by forest and the total area. If the result is closer to the value of 1 the ecological balance is higher. It was calculated only for 2012. The reason was the lack of statistical data prior to 2010. Depending on the value of this index, Manea (2003) proposed six types of landscapes for the Iron Gates Natural Park [12]. This classification was also employed for the Bran-Rucăr-Dragoslavele Corridor [2].

According to this classification, for the different administrative territorial units from the Sub-Carpathian area of the Cricovul Sărat basin, we have identified the following types of landscapes (fig. 8):

- in relatively stable equilibrium (0.45 to 0.60);
- in slightly affected ecological balance (0.30 to 0.45);
- to limit the ecological balance (0.20-0.30);
- in strongly affected ecological balance (0.10-0.20);
- in very strongly affected ecological balance (below 0.10).

The administrative territorial units with the highest share of agricultural land (Gornet, Podenii Noi, Urlați) have the lowest value of the naturality index, below 0.2. This indicates a strongly affected ecological balance (Gornet, 0.10 and Podenii Noi, 0.16) or that the ecological balance is very strongly affected (Urlați, 0.032). Instead, administrative territorial units with the lowest share of agricultural land (Cislău, Lapoș) have the highest value of the naturalness indicator, 0.58 (Lapoș) and 0.57 (Cislău), with relatively stable equilibrium. At the level of the entire territory, the naturality index shows a value of about 0.32 (in 2012), showing a landscape near the limit of ecological balance. These values attest a better balance than the one existing at the level of Romania (0.28 in 2012). At the local level, the best situation is generally registered in the communes north of the river basin (Cislău, Lapoș, Aricești-Zeletin), at higher altitudes. In contrast, the administrative territorial units with a high share of agricultural land, have strongly affected ecological landscapes (Gornet, Podenii Noi) or very severely affected (Urlați).

The environmental transformation index (IET) shows the ratio between the natural and anthropogenic surfaces and can be computed used several forms of calculus. This indicator can be adapted depending on the most powerful intervention in the landscape. Initially, the formula proposed by Maruszczak (1988) was: $IET = (\text{forest area} + \text{meadows area}) / \text{built area}$ [14]. There were and other ways of calculation used in the other studies [12], [6]. The formula used by us was: $IET = (\text{forest area} + \text{aquatic area}) / (\text{agricultural area} + \text{built area})$. It was calculated only for 2012. The reasons are the same as those mentioned for the naturality index. Values less than 1 indicate the dominance of anthropogenic influence, and values greater than 1 indicate the dominance of the natural element; values close to 1 indicate a fragile balance [2]. Cislău (1.50) and Lapoș (1.40) are the administrative territorial units where the natural elements are dominated (fig. 8). In Aricești-Zeletin (1.03) and Iordăcheanu (0.96) values indicates a fragile balance. The most powerful human impact is registered in Urlați city (0.05). At the level of the entire territory, the value was of 0.54 in 2012.

4. CONCLUSION

We believe that the diachronic analysis of the agricultural land use, on the one hand, and of the index of human pressure by land use, of naturality index and of environmental transformation index, on the other hand, helped us to make a good picture of the state of the environment. We were also able to judge the quality of landscapes in the investigated perimeter, which is predominantly rural.

We can consider that the naturality index has a limitation related to the fact that it takes into account the forest area, without taking into account the nature of those fundamental natural forests. Through the plantations they may change the content of species. However, we consider this a valuable tool in evaluating the ecological balance of a territory. In addition, in the studied territory, we believe that existing forests keep, for the most part, the specific composition of the Sub-Carpathian hills. Analysis of the Corine Land Cover database (2006) and the observations made on the ground confirms this [26]. Only in the North-East, in the area of Scărișoara (Cislău commune) there is a small area (of approximately 100 hectares) with mixed forests, at altitudes between 300 and 500 m. Consequently, the presence of some species by coniferous is explained by plantations. In the rest of the territory there are deciduous forests.

Ionescu, Săhleanu & Bândiu (1989), consider that when the natural values drop below 50% negative ecological retroactions occur [27]. By quoting V. Giurgiu (1982), the aforementioned authors argue that the point where reversibility is lost, which is a limit for the

geographical environment of the temperate realm, is a wooded area of at least 25%. Consequently, we can appreciate that at the level of the entire investigated territory the degree of afforestation (32.2%) is close to the critical point, a fact that is shown by the naturalness index. Nevertheless, the value of the environmental transformation index allows us to appreciate that at the level of the Cricovul Sărat watershed anthropogenic influence is still moderate. This is due to the rural character of the investigated territory and to the extension of the areas occupied by pastures and hayfields, which are prevailing in the structure of agricultural lands. These areas may be considered semi-natural, because the vegetal cover is generally made up of spontaneous species, but the structure of this cover is altered to such an extent that it belongs now to another type of vegetation (pasture that invaded a previously forested land) [22]. A moderately balanced to a slightly unbalanced landscape is also shown by the human pressure index mirrored by the use of agricultural lands.

As we have shown, these indicators have a series of limitations. However they offer a range of useful information about the state of the environment. Their quality increases when they are used together. So they complete analysis of a territory. Important are also the maps made with values obtained. Their comparative analysis makes it easier to understand the existing realities. We believe that the analysis performed showed the following: - the level of demographic pressure on the space; - the role of the human factor as user of the natural potential; - the need for interdependence between human actions and environmental balance requirements [28].

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