Assessment of land use changes and landscape fragmentation in the tourism area of Cacica and Vatra Dornei

Vasilică-Dănuț HORODNIC[1]*, Petruț-Ionel BISTRICEAN[1,2], Dumitru MIHĂILĂ[1] and Vasile EFROS[1]
[1]Department of Geography, Faculty of History and Geography, "Ștefan cel Mare" University of Suceava, No. 13, Universității Street, Suceava, Romania
[2]Regional Meteorological Centre of Moldova, National Meteorological Administration, No. 10, Vascăuțeanu Street, Iași, Romania

* Correspondence to: Vasilică-Dănuț Horodnic. E-mail: vasilica.horodnic@gmail.com.

 Vol. 29 / 2019, 12-30

Published:

28 September 2019

ABSTRACT: This paper is intended to evaluate the effects of the development of anthropogenic activities on changes in the way of land is use and in the fragmentation of the landscape in the tourism areas of Cacica and Vatra Dornei (Suceava county). The proposed methodology includes the combination of geographic and cartographic data available, geographic information systems and landscape metrics. Using patches as landscape elements, a series of two-level (class and landscape) hierarchical landscape metrics were chosen to quantify the surface, number and size of landscape units that define the surveyed territory, homogeneity or diversity of the landscape. The ArcGis 10.2.2 software was employed to present the spatial distribution of land use changes over the 22 years (1990-2012) following the processing of the database provided by the European CORINE Land Cover project. The statistical results of the landscape metrics were obtained using the FRAGSTATS 4.2.1 software. The results highlight that, in Cacica landscape, the spatial pattern of land use and cover was dominated by a broadening of agriculture and semi-natural areas to the detriment of artificial surfaces and forests lands. On the other side, in the case of Vatra Dornei, the most prominent landscape changes were represented by afforestation and urbanization. The present study reveals a decrease of fragmentation for Caccia and an increase of fragmentation for Vatra Dornei which obviously contributed to the modification of the local landscape structure. Therefore, research findings underline the importance of supporting the geo-diversity of landscapes as they can provide additional tourist income and support the proper use of land.

KEY WORDS: land use, landscape metrics, conversion, fragmentation, patch.

1. Introduction

The recent findings showed that spatial and temporal changes at the level of land cover caused by human-environmental processes have become a current research direction for the investigation of landscape structure, landscape pattern and its dynamics.

Changes in land use are considered to be the most significant alteration in the earth's surface, with numerous implications ranging from biodiversity alteration to a decrease in human well-being (Antrop, 2005; Fischer & Lindenmayer, 2007; Turner, Lambin, & Reenberg, 2007). These events highlight the importance of the research of landscape changes for environmental sustainability and conservation purposes (Antrop, 2005; Bürgi et al., 2007; Marcucci, 2000).

Since the end of World War II, the general decline of traditional mountain farming activities has led to an extensive reduction of meadows, coupled with woodland recovery after land abandonment, as well as to an increase in infrastructure and services devoted to leisure (European Environmental Agency, 2006). However, these processes can vary over a certain territory depending on local environmental features, socio-economic activities determined by the specificity of land use planning and policy measures.

Tourism activities reflect the interaction between man and the natural environment, in other words, how man exploits the natural resources with tourism potential existing within a certain territory. This will influence the landscape in three ways "subordinating" of a new socio-cultural and natural modeling: setting up a certain land use typology (functional changes); changes in the landscape pattern (structural changes) and physiological modifications (shape, appearance). All of these characteristics vary in time and space inducing a particular dynamics of landscape pattern.

Tourism development can strongly affect the land use/land cover structure, both in terms of landscape composition and spatial configuration. Moreover, the effects of development in tourism locations cannot be easily be detected regarding structural changes induced by tourist activities at the level of land use/land cover pattern. Consequently, a fine scale analysis of land use change is very important in order to identify and to implement the appropriate measures for sustainable development policies.

In Romania, different geographical approaches regarding land use/land cover change research methods by means of geographical information systems have been emerged after 1990. However, few studies have been aborded the relationship between land use/land cover changes and landscape fragmentation in tourism destinations by application of landscape metrics. In our country, the application of landscape metrics in landscape research was applied to particular territorial units, such as the Transylvanian Plain (Schreiber et al., 2003), the Prahova Valley (Pătru-Stupariu et al., 2009), the Buzău Subcarpathians (Niculae & Pătroescu, 2011), the Iași Metropolitan area (Cîmpianu & Corodescu, 2013), the Cluj-Napoca periurban area, the Site of Community Interest ROSCI0358 Pricop-Huta-Certeze or the Site of Community Interest ROSCI0233 Someșul Rece respectively (Corpade et al., 2014, 2016), Piatra Craiului National Park and Bucegi Natural Park (Vorovenecii, 2015) or the Nera Gorges-Beuşniţa National Park and its vicinity (Ianăș & Germain, 2018).

The main goal of the present paper is to to detect, quantify and characterise the changes of land use/cover and landscape fragmentation in a two tourism area (Cacica and Vatra Dornei) from

Suceava county, North-East Development Region of Romania by the application of a diachronic analysis of freely available CORINE Land Cover data, landscape metrics and GIS techniques.

In order to accomplish the above aim, the objectives of present study are to: harmonize and process a database regarding land cover and land use using CORINE Land Cover datasets and GIS techniques; identify and analyse the spatial distribution of changes; generate the transition matrix; identify the rate of change for all classes of land use/cover identified at the level of lanscape of two study sites and to assess the landscape fragmentation by the application of relevant landscape metrics.

1.1. Study area

The study area is represented by two tourism locations with natural therapeutic factors and covers a total surface of 15494.2 ha. The first area under study is represented by Cacica, a rural locality of 5511.33 ha, situated between following coordinates: 47°38'16" northern parallels, and 25°53'56" eastern meridians. The second area chosen for this study is represented by Vatra Dornei, an urban locality of 9982,87 ha, situated between following coordinates: 47°20'46" northern parallels, and 25°21'34" eastern meridians (Vatra Dornei), as they are cartographically presented in figure 1.

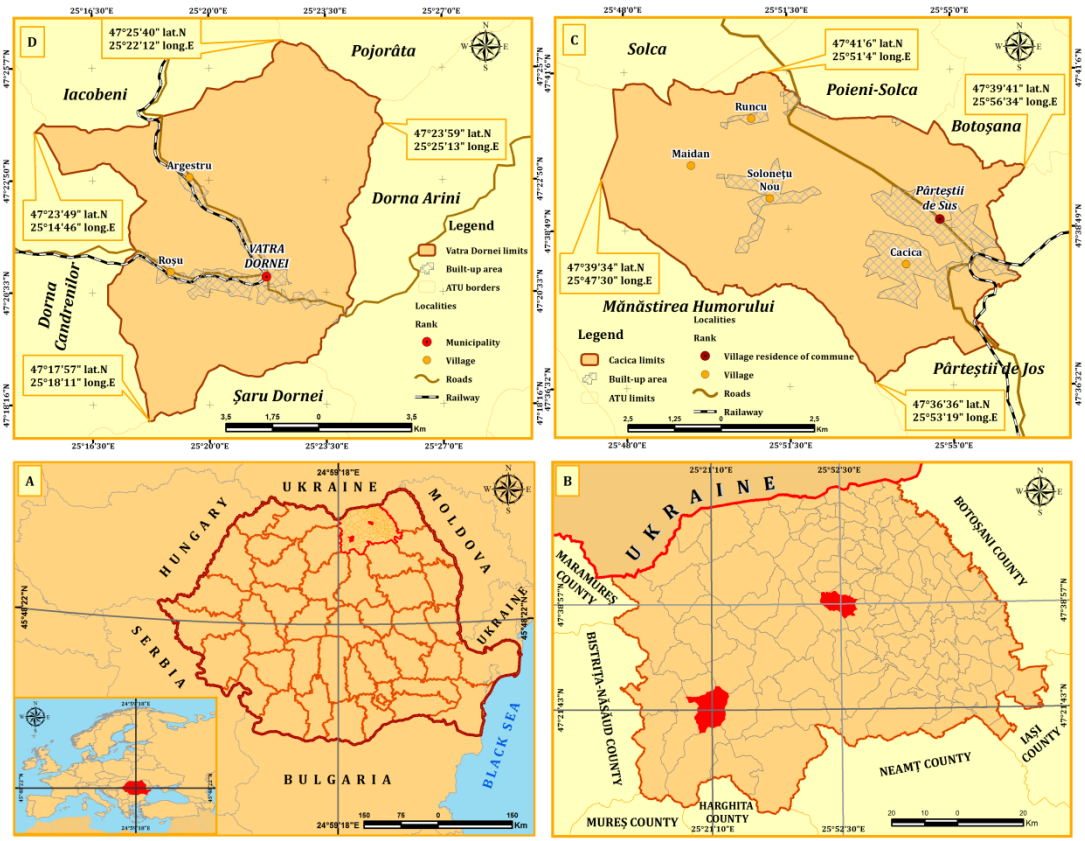

Figure 1 Geographical position of the study area.

With a population of 3712 inhabitants at the last National Census (2011), the Cacica commune is a medium administrative-territorial unit situated in the central-eastern part of the Suceava county, in the Solca-Cacica Depression at the eastern edge of the Bukovina Ridges at an average altitude of about 428 meters. The locality is weel-known by the fact that there was one of the oldest

recrystallized brine salt (boiling and evaporation) in Europe (Cacica saline), dated from Starčevo-Criş culture in the early Neolithic as well as the fact that there are several salty springs in the area. From an socio-economic point of view, the area under study is dominated by forests lands with a percentage of 43.90% of the total area, following by agricultural areas (39.25%), but the highest degree of employment rate of population is in the primary sector (24.67% in 2011).

The other side, with a population of 14429 inhabitants (NIS, 2011), Vatra Dornei is the fifth urban center of Suceava County, being declared municipality in 2000. Vatra Dornei has been known since the 19th century as a spa resort and for practicing winter sports. It is located in the south-western part of Suceava County, in Dorna Depression at an average altitude of about 809 meters. From an socio-economic point of view, the area under study is dominated by forests lands with a percentage of 55.27% of the total area, following by agricultural areas (33.29%) and a high degree of employment rate of population in the tertiary sector (24.67% in 2011).

2. Materials and Methods

2.1. Data used

The complexity of the research of land use and land cover changes requires an integrated approach research that combines basic geographical principles, specific concepts and particular research methods and techniques of land system investigation. The methodological flowchart is based on several steps which are presented in figure 2.

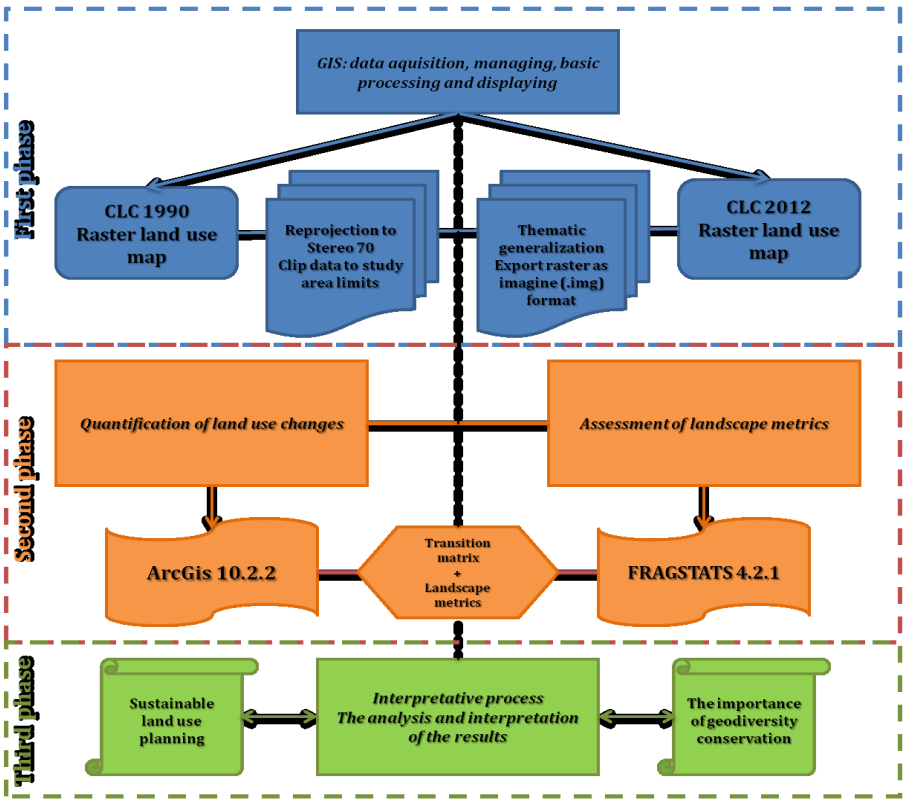

Figure 2 Flowchart of the methodological research steps.

The first step includes GIS basic applications, such as, data aquisition, managing, basic analyzing and displaying of georeferenced data. To highlight the land use/cover changes changes and the landscape fragmentation occurring in the study area, we used two categories of data. The first category is represented by the datasets of the European Environmental Agency (EEA) in the context of the CORINE Land Cover (CLC) project for time steps 1990 and 2012. Secondly, the administrative- territorial units (ATU) limits for the study area and the transportation network data as vector shapefile format were also used.

We used in our analysis the data regarding land use/cover in raster format with 100x100m resolution. We also reproject the initial data to Stereo 70 national coordinate system. Another basic applications include a thematic generalization of land use/cover in order to be able to compare the results and the export of raster data as imagine format for future processing analysis in FRAGSTATS software.

The second phase of analysis consist of quantification of land use/cover changes by means of geographic information systems generating in this way the contingence table (transition matrix). The other side, it was applied an assessment of landscape fragmentation by use of landscape metrics processed in FRAGSTATS software.

Finally, in the third phase of the research, the resulted data was interpreted and analyzed in order to highlight the spatial and temporal pattern of land use and cover changes occured at the landscape level of the study area.

2.2. Land use/land cover classification scheme and change detection

The classification hierarchy applied int he present study is derived from land use land cover classification scheme of the CORINE Land Cover project. The level of aggregattion and particular characteristics of each land use land cover category is presented in the table below (Table 1).

Table 1 Classification scheme applied in the analysis of land cover and land use change dynamics.

Land use and land cover class	CLC 1990-2012 Level 2	Description
Forests	3.1	includes plant communities dominated by broadleaf, evergreen and mixed tree species associated with shrubs, trees canopy covering >50% of the area
Semi natural areas	3.2-3.3	includes vegetation with herbaceous species, low occurrence of shrubs, high herbs in the case of hay fields
Agricultural areas	2.1-2.3-2.4	includes all types of cultivated area, i.e., arable lands, planted or bare crop fields, permanent crops like orchards and vineyards
Artificial surfaces	1.1-1.3	includes highly developed buildings, residential buildings, commercial and industrial units, urban utilities, leisure areas

For each category of land cover and land use, we calculated the total area expressed in hectares (ha) and the percentage (%) of its variation over the time was also quantified. The diachronic analysis gave us valuable information about the changes in terms of total increase or decrease of the individual land use or land cover classes during different time horizons investigated.

In order to obtain the land change map, the land cover and land use maps from 1990 and 2012 were intersected. Geographical distribution of land use land cover categories for the years analysed was performed by creation of thematic land use maps and land change map to highlight the changes that occured at the level of study area.

2.3. Landscape fragmentation

The part of our analysis aimed to address landscape fragmentation in the study area and to analyse the temporal evolution of this basic characteristic of the landscape. Landscape fragmentation was investigated with the landscape metrics calculated at class and landscape level for 1990 and for 2012. According to Leemans (2013), landscape metrics represents a quantitative approach for the evaluation of landscape composition, spatial configuration or its structure.

Investigation of the changes in spatial context of landscape pattern helps us to decipher and to understand the diversity of interconnectedness of human-environmental processes. To explore the level of fragmentation and its spatial configuration, several landscape metrics was calculated for each land use and cover classes at the entire landscape level by means of FRAGSTATS software. A series of 8 landscape metrics used was chosen to describe landscape composition and its spatial configuration (Table 2). The indices present a great potential to quantify the number and size of landscape units.

Regarding the present research of landscape pattern, we employed several integrated methods. First of all, we realised a thematic documentation in point of the subject approached. Secondly, we performed a territorial mapping in order to present the spatial distribution of land usage and coverage. Statistical methods were used for determination of change rate of individual land cover or land use categories.

In order to manipulate CORINE Land Cover data and resulted vector data, we used several software programs: ArcGIS 10.2.2 software for raster analysis and mapping of geographical data, FRGSTATS 4.2.1 software for landscape metrics selection and processing and Microsoft Office Excel 2010 for graphical representation.

3. Results

3.1. Quantification of land use and land cover changes

Land use is historically very dynamic in space and time and causes changes in landscape structure. After the fall of the socialism regime, Romania has known profound socio-economic, institutional, technological and cultural transformations which are well expressed in land use/cover spatial pattern.

The distribution of land use and land cover categories in the study area are diversified, 8 land use/cover classes being identified according to the level 2 classification scheme of CORINE Land

Cover data at the level of study area. These were generalised in four land cover categories were identified at the level 1 of classification scheme of CORINE Land Cover data. This includes forests, semi natural areas, agricultural areas and artificial surfaces.

Table 2 Landscape metrics included in the analysis.

Index name	Description	Units/value range	References
Number of Patches (NP)	Total number of patches in a particular class or an entire landscape.	(None)/(NP ≥ 1, without limit)	McGarigal and Marks (1995)
Largest Patch Index (LPI)	It equals the percentage of the landscape comprised by the largest patch.	(%)/(0 < LPI ≤ 100)	McGarigal and Marks (1995)
Total Edge (TE)	Is an absolute measure of total edge length of a particular patch type.	(m)/ (TE ≥ 0, without limit)	McGarigal and Marks (1995)
Mean Patch Size (AREA_MN)	Average size of patches from a specific class.	(ha)/(MPS > 0, without limit)	McGarigal and Marks (1995)
Mean Proxmity Index (PROX_MN)	Quantifies the spatial context of a patch in relation to its neighbors of the same class.	(None)/(PROX ≥ 0)	McGarigal and Marks (1995)
Mean Euclidean Nearest Neighbor Distance (ENN_MN)	Measure the distance between the two patches of the same type and indicates the isolation degree.	(m)/ (0 < LPI ≤ 100)	McGarigal and Marks (1995)
Interspersion and Juxtaposition (IJI)	Provides information about isolation the interspersion or intermixing of patch types	(%)/(0 < IJI ≤ 100)	McGarigal and Marks (1995)
Effective Mesh Size (MESH)	Size of remaining residual areas; expresses the probability that two points chosen randomly in a region are connected.	(ha)/(ratio of cell size to landscape area ≤ MESH ≤ total landscape area)	McGarigal and Marks (1995)

Land use coverage is conditioned by the geological formations, geomorphologic features, climatic conditions and by socio-economic profile of the areas studied. The human-environment interaction generate the diversity of land usage but at the same time a mosaic of land. A special category of the societal needs are often linked to leisure activities which includes tourism development with special infrastructure (transport network, ski slope, accommodation units, alternative entertainment activities etc).

The spatial distribution of land fund's structure is presented in figure 3. We can notice that forests is the most predominantly land cover category in the study area (over 40% in Cacia and over 50% in Vatra Dornei) followed by agricultural areas (about 40% in Cacica and over 30% in Vatra Dornei

total area), artificial surfaces (over 10% in Cacica and below 10% in Vatra Dornei), while semi natural areas occupy the smallest surface (over 3% in Cacica and 5% in vatra Dornei) according to statistical situation presented in figure 4.

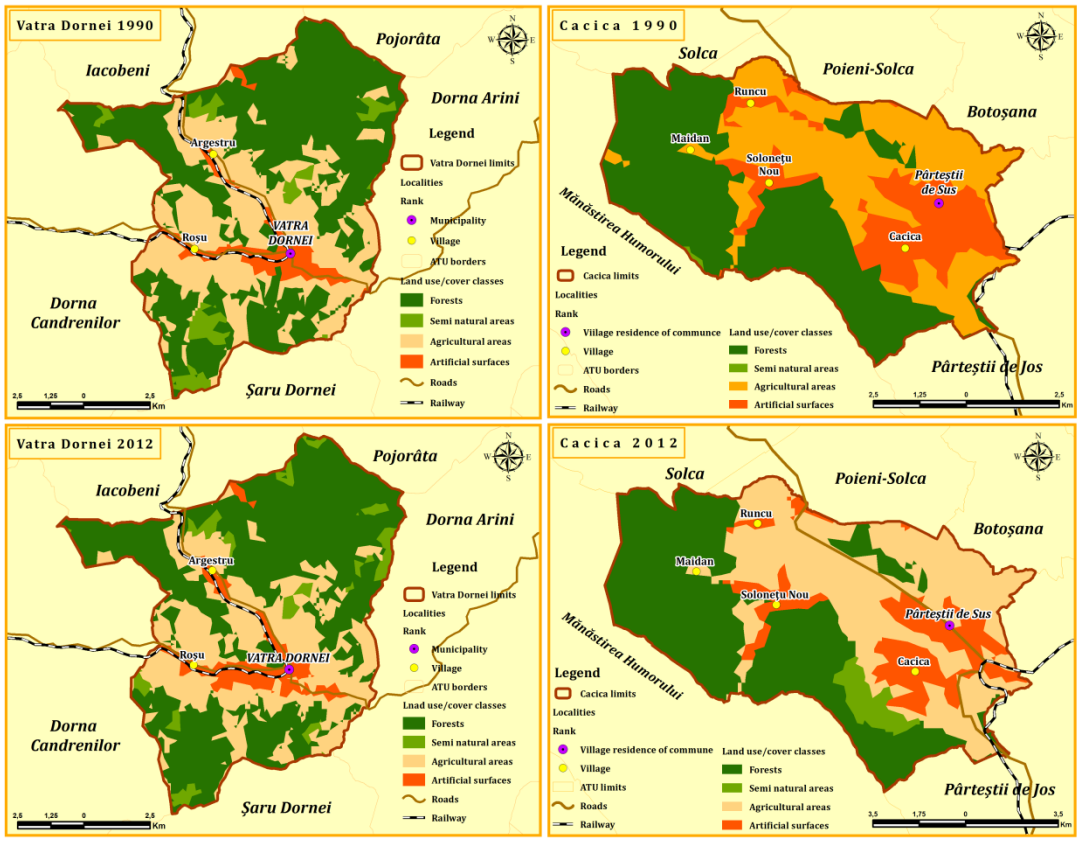

Figure 3 Land cover and land use distribution in Cacica and Vatra Dornei between 1990 and 2012.

The surface (ha) and percentage (%) of land use land cover categories in the study area for 1990-2012 time horizon are well presented in table 3 for Cacica and table 4 for Vatra Dornei. In order to calculate and determine the annual change rate of land use/cover at class level for the period analysed in this study we applied the following formula (Equation 1):

$$A_{ca} = \frac{\left(\frac{T_{ca}}{S_{t1}} \times 100\right)}{T} (\%) \qquad (1)$$

where, T_{ca} is the total changed area between start and end date, respectively, S_{t1} is the total area at strat time of period, and *T* is the time period. A_{ca} represent the annual change rate of particular class within the study area during *t* (time horizon under analysis - 22 years in our case).

Both in Cacica and Vatra Dornei, the forestry hold the highest area, but the dynamic is different for two localities. If in the case of Cacica, this land use/cover category registered a decrease of 139.10 ha (-2.52%) from 2558.52 ha (46.42%) in 1990 to 2419,42 ha (43.90%) in 2012 that means an annual decreasing rate of 0.25 %/year, in the case of Vatra Dornei, forest land registered an increase of 197.60 ha (1.98% from total area) from 5319,46 ha (53.29%) in 1990 to 5517.06 ha (22.27%) in 2012, which determined an annual increasing rate of 0.17%/year.

Table 3 Overall amount, extent and rate of land use/cover change in Cacica (1990-2012).

Land use/cover classes	Area 1990		Area 2012		Total change 1990-2012		Rate of change 1990-2012 (%)	
	ha	%	ha	%	ha	%	22 years	yearly
Forests areas	2558.52	46.42	2419.42	43.90	-139.10	-2.52	-5.44	-0.25
Semi natural areas	9.68	0.18	178.58	3.24	168.90	3.06	1744.83	79.31
Agricultural areas	1925.33	34.93	2163.11	39.25	237.78	4.31	12.35	0.56
Artificial surfaces	1017.80	18.47	750.22	13.61	-267.58	-4.86	-26.29	1.20

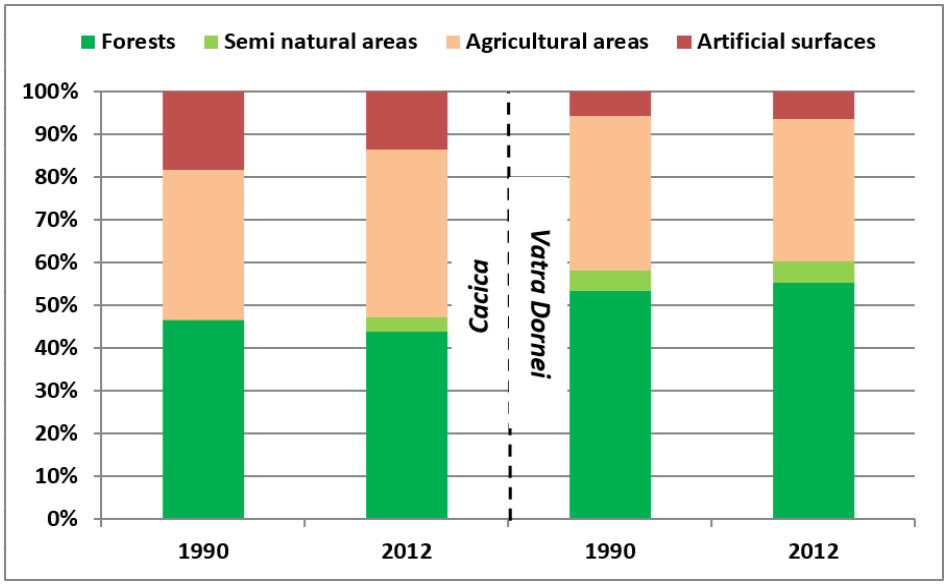

Figure 4 The percentage of land use/land cover classes in Cacica and Vatra Dornei.

Table 4 Overall amount, extent and rate change of land use/cover change in Vatra Dornei (1990-2012).

Land use/cover classes	Area 1990		Area 2012		Total change 1990-2012		Rate of change 1990-2012 (%)	
	ha	%	ha	%	ha	%	22 years	yearly
Forests areas	5319.46	53.29	5517.06	55.27	197.60	1.98	3.71	0.17
Semi natural areas	484.11	4.85	501.22	5.02	17.11	0.17	3.53	0.16
Agricultural areas	3602.08	36.08	3323.34	33.29	-278.74	2.79	-7.74	-0.35
Artificial surfaces	577.22	5.78	641.25	6.42	64.03	4.07	11.09	0.50

The most significant dynamic was registered by artifical surfaces in the case of Cacica, from 1017.80 ha (18.47%) to 750.22 ha (13.61%), thus a total decrease of 267.58 ha (4.86%) determining a magnitude of change characterised by an annual decreasing rate of 1.20%/year. The other side, in Vatra Dornei, agricultural areas class has registered the significant dynamic which was about of -278.74 ha (2.79%) with an anual decreasing rate of -0.35%/year. We observed also differences as respects the high values of yearly rate of change. In this case, semi natural areas registered the high rate of change for Cacica namely 79.31%/year, while in Vatra Dornei, artificial surfaces registered the maximum values of annual growth rate of 0.50%/year.

To provide a further comprehensive analysis, the calculation in losing and gaining areas among the four land use/cover classes, the from-to change transition matrix were generated for 1990-2012 interval. In cross tabulation, the unchanged values were located along the major diagonal of the matrix while conversions values of classes were arranged in descending order. The results of the from-to matrix of changes can be observed in table 5 and figure 5 for Cacia and table 6 and figure 6 for Vatra Dornei.

Table 5 Contingence matrix (values in ha) corresponding to the two datasets in Cacica area.

		2012				
		Forests areas	Semi natural areas	Agricultural areas	Artificial surfaces	Total 1990
1990	Forests areas	2336.23	172.96	42.17	7.16	2558.52
	Semi natural areas	9.68				9.68
	Agricultural areas	59.90	2.24	1828.00	35.18	1925.33
	Artificial surfaces	13.61	3.37	292.94	707.88	1017.80
	Total 2012	2419.42	178.58	2163.11	750.22	5511.33

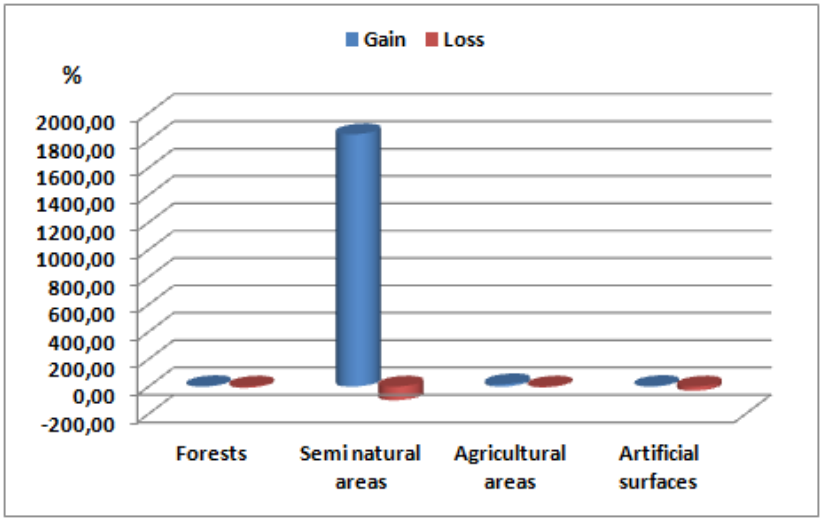

Figure 5 Gains and losses of land use/land cover classes in Cacica.

In this way, at the level of Cacica administrative-territorial unit we can notice that the entire surface of semi natural areas converted into forests 9.68 ha (100%), followed by artificial surfaces with a total conversions of 309.92 ha (30.45%) and forests lands with a net loss of 222.29 ha (8.69%). Compared to 1990, the agricultural areas recorded the smallest losses in surface, approximately 97.33 ha (5.05%) in the conditions which this land use category registered the the highest gains in area, namely 335.11 ha (17.41%) while semi natural areas registered the highest gains in area about 178.58 ha (1845.10%). Thus, for Cacica administrative-territorial unit the spatial pattern of land use and cover was dominated by an extensification of agriculture and semi natural areas to the detriment of artificial surfaces and forests lands.

The other hand, at the level of Vatra Dornei urban area, compared to 1990, the brute values present a different situation: forests registered the highest values of gains about 688.50 ha (12.94%) and agricultural areas recorded the highest valus of losses namely 660.27 ha (18.33%) what means a loss of 30.10 ha/year.

Table 6 Contingence matrix (values in ha) corresponding to the two datasets in Vatra Dornei area.

		2012				
		Forests areas	Semi natural areas	Agricultural areas	Artificial surfaces	Total 1990
1990	Forests areas	4828.55	215.78	267.71	7.41	5319.46
	Semi natural areas	294.67	165.21	24.23		484.11
	Agricultural areas	378.45	120.23	2941.81	161.59	3602.08
	Artificial surfaces	15.39		89.59	472.24	577.22
	Total 2012	5517.06	501.22	3323.34	642.25	9982.87

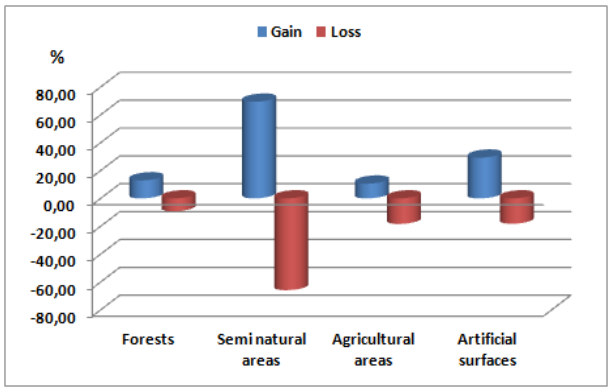

Figure 6 Gains and losses of land use/land cover classes in Vatra Dornei.

Thus, the most visible conversions at the level of Vatra Dornei were recorded for semi natural areas with a total area changed of 318.90 ha (65.87%), followed by agricultural areas with 660.27 ha (18.33%) and artificial surfaces with 104.97 ha (18.19%) while forests lost 490.90 ha (9.23%) during the span of 22 years. In this case, the most prominent landscape changes were represented by afforestation and urbanization, as a consequence of agricultural land abandonment and the expansion of tourism infrastructure (construction of tourism facilities).

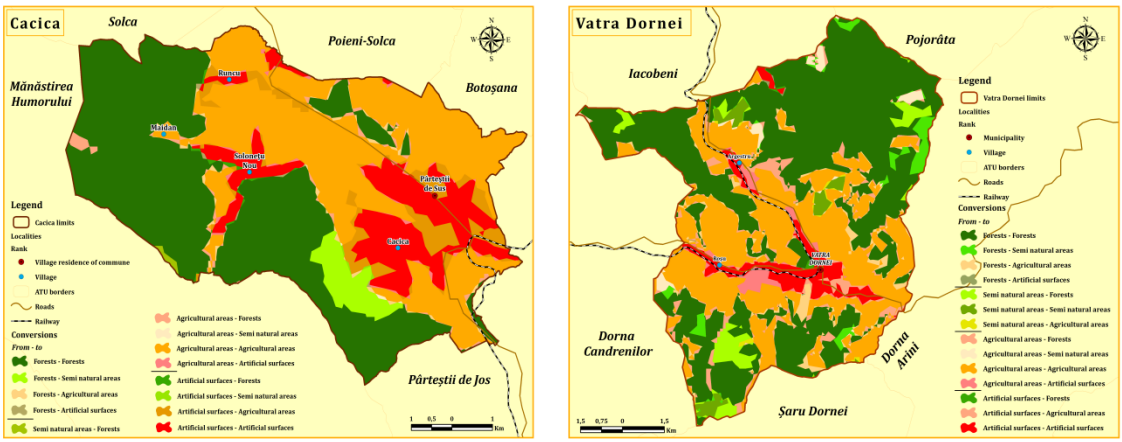

Figure 7 Spatial pattern's distribution of land cover and land use changes in Cacica (left) and Vatra Dornei (right).

The land use changes is one of the investigated phenomena that need to be assessed in every aspect of processes that contribute of its manifestation in time and space. Figures 7 below show the spatial distribution of land use land cover conversions between 1990 and 2012.

During the 22 years, an area of 639.21 ha which represented 11.60 % from the total area of the Cacica commune was affected by changes, while the territory of Vatra Dornei affected by changes have reached a total surface of 1575.05 ha (15.78%). This fact highlights the effect of changes in political, institutional, economic and social factors after the the fall of the socialism regime and, more important, the transition to market economy with visible implications in land usage of the territory.

3.2. Assessment of landscape fragmentation

Outputs of the landscape quantification are numerical values that can be interpreted toward effects of development on land use changes. In our analysis we have chosen 8 landscape metrics (number of patches, largest patch index, total edge, mean patch size, mean proximity index, mean euclidean nearest neighbor distance, interspersion and juxtaposition and effective mesh size) to assess the landscape fragmentation of the study area. For this, we rule the model parameterized using an 8-neighbor rule in FRAGSTATS software for land use/cover classes identified at the level of the studied areas.

The landscape metrics computed for Cacica (table 7) of forests areas showed that the number of patches increased from 6 to 8 units during the whole period from 1990 to 2012. This fact suggests the breaking up of forestry areas into smaller patches (parcels). This is alos supported by the largest patch index which decreased from 43.97% in 1990 to 41.33% in 2012 and by the mean patch size (426.45 ha in 1990 and 302.65 ha in 2012). The increasing of mean proximity index (defined by 100 m) from 79.70 to 100.00 indicated that forest patches in 2012 became more contigous in spatial distribution than in 1990. This was asserted once again by the decreasing of mean euclidean nearest neighbor distance from 246.30m to 162.36m and the interspersion and juxtaposition index which increased from 57.96% in 1990 to 71.48% in 2012. The smaller values of total edge and effective mesh size together with the values of other indices suggest that the patches became less isolated in spatial distribution.

In regards to agricultural areas during the analysed period, the number of patches decreased from 8 to 6, largest patch index increased from 27.87% in 1990 to 31.83% in 2012, mean patch size increased from 240.67 ha to 360.50 ha, the mean euclidean nearest neighbor distance decreased from 288.66 m to 143.60 m, the interspersion and juxtaposition increased from 62.51% to 76.23%. The higher values of total edge, proximity index and effective mesh size suggest that the patches became more contigous in spatial distribution in 2012 than in 1990.

The statistical results of artificual surfaces showed a decrease of number of patches from 9 in 1990 to 6 in 2012, a decrease of largest patch index from 13.71% to 10.00%, a decrease of proximity index from 188.13 to 8.97, a decrease of interspersion and juxtaposition from 43.00% to 37.33% and alos a decrease of effective mesh size from 108.93 ha to 59.11 ha. Total edge index recorded an increase from 51810 m to 55770 m, the mean patch sise from 113.02% to 124.74% and the mean euclidean nearest neighbor distance from 396.95% to 777.33%. These values revealed that in 2012 artificial surfaces were less fragmented, more isolated, irrelgular and higher in extent area.

Semi natural areas registered during the 1990-2012 interval the same number of patches (1 unit), significant increasing of the others indices: largest patch index from 0.17% to 3.23%, total edge from 1260 m to 10380 m, mean patch size from 9.27 ha to 177.93 ha, interspersion and

juxtaposition from 0.00% to 75.12% and effective mesh size from 0.02 ha to 5.75%. These values highlight that semi natural class has become larger in surface expansion.

Table 7 Calculation results for landscape metrics at class level for Caica in 1990 and 2012.

Landscpe metrics/Land use land cover	Year	NP	LPI (%)	TE (m)	AREA_ MN (ha)	PROX_M N	ENN_M N (m)	IJI (%)	MESH (ha)
Forests	1990	6	43.97	44460	426.45	79.70	246.30	57.96	1067.22
	2012	8	41.33	44220	302.65	100.00	162.36	71.48	943.46
Semi natural areas	1990	1	0.17	1260	9.27	0.00	N/A	0.00	0.02
	2012	1	3.23	10380	177.93	0.00	N/A	75.12	5.75
Agricultural areas	1990	8	27.87	76290	240.67	10.20	288.55	62.51	444.60
	2012	6	31.83	84810	360.50	475.81	143.60	76.23	575.54
Artificial surfaces	1990	9	13.71	51810	113.02	188.13	396.95	43.00	108.93
	2012	6	10.00	55770	124.74	8.97	777.33	37.33	59.11

On the other hand, the Vatra Dornei landscape has known a different evolution of landscape metrics computed between 1990 and 2012 (Table 8). The statistic of forestry areas showed that the number of patches have remained the same, while the largest patch index registered a small decrease from 30.44% to 29.62%, total edge from 202440 m to 192600 m, mean proximity index from 948.77 to 879.13, mean euclidean nearest neighbor distance from 131.71 m to 117.40 m and effective mesh size from 1062.88 ha to 1055.33 ha. The higer values of mean patch size from 177.33 ha to 184.03 ha or the interspersion and juxtaposition from 51.77% to 57.86% in 1012 than in 1990 suggest that fact that forest class became larger in surface and more compact in spatial distribution.

The statistical results of landscape metrics for semi natural class showed that the number of patches increased from 14 in 1990 to 21 in 2012, the mean proximity index recorded an increase of 1.79 units from 0.31 in 1990 to 2.10 in 2012, while the other indices have decreased. These values reveal a fragmentation of semi natural class and the patches tend to become more isolated in spatial configuration.

In regards to agricultural areas, the number of patches decreased from 32 to 26, largest patch index increased from 24.77% in 1990 to 27.35% in 2012, total edge decreased from 211290 m to 204930 m, mean patch size increased from 112.55 ha to 127.70 ha, the mean proximity index increased from 505.23 to 967.62, the mean euclidean nearest neighbor distance decreased from 248.24m to 235.47m, the interspersion and juxtaposition increased from 58.69% to 68.16% and the effective mesh size recorded an increase of 83.7ha. This trend of landscape metrics for agricultural areas class suggest a decrease of landscape fragmentation and the fact that the patches became more isolated and uniform in spatial distribution in 2012 than in 1990.

The landscape metrics computed for artificial surfaces class from Vatra Dornei showed that the number of patches have remained the same (6 units), the largest patch index increased from 4.83% to 5.30%, the total edge index increased from 41460 m to 47520 m, the mean patch area increaed from 96.30 ha to 107.16 ha, the effective mesh size have also increased from 23.67 ha to 28.80 ha, while the mean proximity index decreased from 13.06 to 11.77, the mean euclidean nearest neighbor distance decreased from 619.55 m to 410.24 m and the interspersion and juxtaposition decreased from 46.06% to 37.91%. In this case, the statistical results reflect a less

uniform configuration of this class in the whole Vatra Dornei landscape, while the patches that define the artificial surfaces class became larger in surface in 2012 than in 1990.

Table 8 Calculation results for landscape metrics at class level for Vatra Dornei in 1990 and 2012.

Landscpe metrics/Land use land cover	Year	NP	LPI (%)	TE (m)	AREA_ MN (ha)	PROX_MN	ENN_M N (m)	IJI (%)	MESH (ha)
Forests	1990	30	30.44	202440	177.33	948.77	131.71	51.77	1062.88
	2012	30	29.62	192600	184.03	879.13	117.40	57.86	1055.33
Semi natural areas	1990	14	1.38	40230	34.66	0.31	892.34	55.98	4.31
	2012	21	0.87	52410	23.79	2.10	709.06	55.38	2.44
Agricultural areas	1990	32	24.77	211290	112.55	505.23	248.24	58.69	674.27
	2012	26	27.35	204930	127.70	967.62	235.47	68.16	757.97
Artificial surfaces	1990	6	4.83	41460	96.20	13.06	619.55	46.06	23.67
	2012	6	5.30	47520	107.16	11.77	410.24	37.91	28.80

The values obtained from landscape metrics calculations at landscape level for Cacica (Table 9) highlights that in the analysed period, the number of patches recorded a small decrease from 24 to 21 units, the largest patch index expresses also a decrease, from 43.97% in 1990 to 41.33% in 2012 and the values of effective mesh size registered a small decrease from 1620.77 ha in 1990 to 1583. 86 ha in 2012. The total edge metrics recorded a small increase from 86910 m in 1990 to 97590 m in 2012, the mean patch size index registered an increase in 2012 (262.41 ha) compared with 1990 (229.61 ha). The mean proximity index defined by a limit of 100 meters, recorded an increase of 44.98 units, the mean nearest neighbour distance increased by 21.27 m, while the interspersion and juxtaposition index recorded an increase of 11.37%, from 56.855 in 1990 to 68.22% in 2012. All values of this landscape metrics reflect a decrease of fragmentation sustained by the reduction in number of patches, the increase of the mean patch size or the increase of the mean nearest neighbour distance while the downward trend of the values of the other landscape metrics highlight the fact that landscape units have defined a more contigous distribution in the landscape of Cacica administrative-territorial unit.

Table 9 Metrics of landscape structure for selected indices at the landscape level in 1990 and 2012.

Landscpe metrics/Land use land cover	Year	NP	LPI (%)	TE (m)	AREA_ MN (ha)	PROX_M N	ENN_MN (m)	IJI (%)	MESH (ha)
Cacica	1990	24	43.97	86910	229.61	93.88	319.95	56.85	1620.77
	2012	21	41.33	97590	262.41	138.86	341.22	68.22	1583.86
Vatra Dornei	1990	82	30.44	247710	121.75	545.28	342.74	58.44	1765.13
	2012	83	29.62	248730	120.29	622.25	325.25	64.71	1844.54

The other side, Vatra Dornei administrative-territorial unit has known an inverse evolution of landscape fragmentation (Table 9). In this case, the number of patches registered a small increase, from 82 to 83 units in 1990-2012 time horizon, the largest patch index recorded a small decrease from 30.44% in 1990 to 29.62% in 2006. The values of effective mesh size registered a small increase, from 1765.13 ha in 1990 to 1844.54 ha in 2012. The total edge metrics recorded a small increase from 247710 m in 1990 to 248730 m in 2012, the mean patch size index registered a decrease in 2012 (120.29 ha) compared with 1990 (121.75 ha). The mean proximity index defined

by the same limit of 100 meters, recorded an increase of 76.97 units, the mean nearest neighbour distance decreased by 17.49 m, while the interspersion and juxtaposition index recorded an increase of 6.27%, from 58.44% in 1990 to 64.71% in 2012. Thereby, all values of landscape metrics analysed reflect an increase of fragmentation sustained by the growth in number of patches and by the decrease of the mean patch size, while the upward trend of the values of the other landscape metrics (effective mesh size, total edge, the mean proximity index or the interspersion and juxtaposition index) highlight the fact that landscape units have become more isolated and dispersed in the area of Vatra Dornei Municipality.

4. Discussions

The most challenging aspects of landscape pattern analysis are selecting the correct spatial metrics to capture the phenomenon being studied and accurately interpreting the results (Li et al. 2005). Land use and cover changes reflect landscape pattern (planned or unplanned) in response to economic, social, political and physical geography of an area.

Changes in the number of landscape units, their shapes and size and the increase of the contigous spatial distribution degree for Cacica landscape, reveal a decrease of the fragmentation process, beginning with 1990. The increase of mean patch size from 229.61 ha in 1990 to 262.41 ha in 2012, confirms the decrease of fragmentation, as also demonstrated by decreases in the total number of patches and decreases of effective mesh size index from 1620.77 ha in 1990 to 1583.86 ha in 2012. The increase of semi natural areas demonstrates that the Cacica landscape fallows a process of renaturation.

Instead, the Vatra Dornei landscape fallowed in 1990-2012 period an active process of fragmentatioin, proof being the increase in the number of patches, the decrease in their size or largest patch index. However, the patches became more contigous in spatial distribution and have a uniform configuration, as a conseqqunce of high degree of mean proximity index, the interspersion and juxtaposition index or the effective mesh size index .

Our study was an attempt to quantify and to establish posssible connections among land cover and use changes and landscape fragmention in two pilot tourist areas from Suceava county. In order to obtain reasonable results we present in a first phase a spatial and statistical analysis of that aspects. Moreover, we collect some statistic data from National Institute of Statistics of Romania as far as that goes the number and the accommodation units of Cacica and Vatra Dornei, because the tourism is not just a spatial component, but a social phenomenon.

The analysis of touristic data regarding the number of tourists in Cacica (Figures 8) shows an increase from 1482 tourists in 2012 to 6820 tourists in 2017, but the highest nubmer of tourists was recorded in 2016 (7617 tourists) with an growth rate of 111.41% from previous year (3603 tourists in 2016). For a more comprehensive analysis, we took into consideration and the number of accommodation units as a reliable indicator of tourism development. In this case, the number of accommodation units also increased from 2 units in 2012 to 9 units in 2017, that means a growth rate of 350% in 2012-2017 period (Figure 9).

The statistic data of number of tourists and accommodationn units of Vatra Dornei are graphically presented in Figures 10 and 11. The analysis of the number of tourists reveals that it fallowed an oscillating trend between 2001 and 2017, with a minimum of 35844 tourists in 2011 and a maximum of 51430 tourists in 2008. However, the highest growth rate was registered in 2006

(12.26%) compared to the previous year. The tendency of tourists number present an general increase from 38212 tourists in 2001 to 50031 tourists in 2017 (a growth rate of 30.93%). The other side, the number of accommodation units has increased continously from 24 units in 2001 to 57 units in 2017 (a growth rate of 137.50%). Only 2006 and 2013 years presented a small decrease according to the previous years taken into analysis, insted the final period beginning with 2014 present a constantly increase.

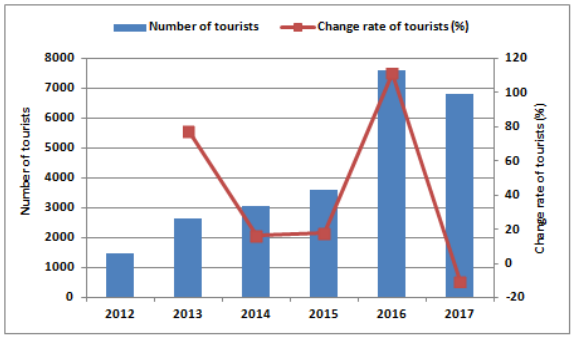

Figure 8. The number and the change rate of tourists in Cacica (2012-2017)

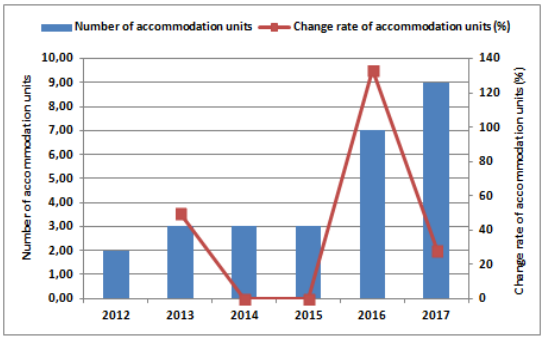

Figure 9. The number and the change rate of accommodation units rate in Cacica (2012-2017)

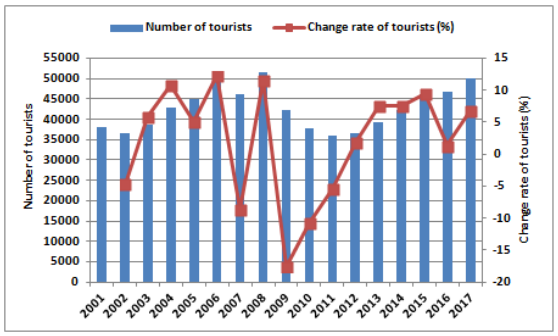

Figure 10. The number and the change rate of tourists in Vatra Dornei (2001-2017)

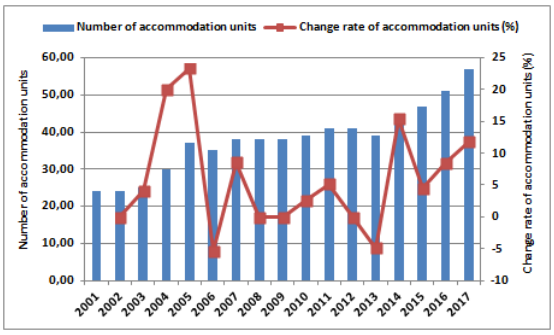

Figure 11. The number and the change rate of accommodation units in Vatra Dornei (2001-2017)

This type of analysis allow us to depict some remarks as reasonable arguments regarding the tourism development under the study area on the one hand, and to forecast the possibilities of developement of tourist activities thanks in particular to the increase of accommodation units both in Cacia and Vatra Dornei tourism area. This aspect is also sustain by the increasing number of yearly tourists, but in our case we pay attention to the land which will be used as a support for tourism development, namely the possible conversions of forestry and semi natural areas into artificial surfaces (accommodation units, transportation network, ski slope and other tourist facilities). But are this touristic locations suitable to tourism development according to the population structure? This fact is reflected in the table 10, which highlight the differences of the emplyoment rate at the level of Cacia and Vatra Dornei administrative-territorial units.

Thereby, we can notice that the emplyment rate does not reach the 50 percent threshold both in Cacica (47.71%) and Vatra Dornei (40.47%) in 2011 according to the statistic data from National Institute of Statistics. Moreover, the two locations present a different economic profile regarding the active population occupied in different sectors of economy: if in Cacica prevails the population occupied in primary sector with 30.25%, so more than a half from total employment rate, in Vatra Dornei is reflected the urban status, 24.67% of emplyoment rate being represented by the tertiary sector (more than a half of emplyment rate). In the case of tourism development, the highly

qualified workforce will present a great advantage in short and medium term of tourism development.

Table 10 The rate of employment by main sectors of activity in 2011 for Cacica and Vatra Dornei.

Main sectors of activity	Cacica		Vatra Dornei	
	Number of persons	%	Number of persons	%
Primary sector	1123	30.25	439	3.04
Secondary sector	235	6.33	1841	12.76
Tertiary sector	413	11.13	3559	24.67
Total	1771	47.71	5839	40.47

5. Conclusions

Tourism activities usually affects the way of land is use. In this study we applied a geographical approach in order to highlight the changes occured at the level of landscape pattern in two tourism locations from Suceava county with therapeutic natural factors. Proposed methodology aplied is just a preliminay approach for more detailed studies that can be made in the near future. In this context, one of the main limitations of present study is represented by scale resolution of data and temporal pattern undertaken in analysis.

The influence of tourism cannot be easily detected in case of small magnitude of tourism development. The usefulness of landscape metrics as tool to quantify landscape fragmentation is strongly influenced by the appropriate landscape indices chosen according to the specifity of the study area, its extent, the resolution of input data and, the most important, by the aim of the own research.

Study area encountered several land use/cover changes during the last 22 years. Thus, for Cacica administrative-territorial unit the spatial pattern of land use and cover was dominated by an extensification of agriculture and semi natural areas to the detriment of artificial surfaces and forests lands. The other side, in the case of Vatra Dornei, the most prominent landscape changes were represented by afforestation and urbanization, as a consequence of agriculatural land abandonment and the expansion of tourism infrastructure (development of tourist facilities).

The present study reveals a decrease of fragmentation for Cacica and an increase of fragmentation for Vatra Dornei which obviously determined the modification of the local landscape structure and fizionomy. This process is clearly highlighted by the temporal changes of landscape metrics and the values obtioned from the contigence tables.

The future analysis of land use changes as a strongly caused of landscape fragmentation will be necessary to be implemented by other perspectives of investigation such as landscape perception or local land use planning by the application of strategic measure of sustainable development. The results could reveal real dysfunctionalities of the present territorial organization. Consequently, appropriate measures should be taken concerning the future land use planning, in order to sustain the tourism exploitation of the landscape potential and to preserve the importace of ecosystem services.

References

Antrop, M. (2005). Why landscape of the past are important for the future. Landscape and Urban Planning, 70, 21–34.

Bürgi, M., & Gimmi, U. (2007). Three objectives of historical ecology: The case of litter collecting in Central European forests. Landscape Ecology, 22(1), 77–87.

Cîmpianu, C. & Corodescu E. 2013. Landscape dynamics analysis in Iași Metropolitan Area (Romania) using remote sensing data.. *Cinq Continents* **3** (7): 18-32 [Available online]| URL : http://www.cinqcontinents.uv.ro/3/3_7_Cimpianu.pdf.

Corpade, C., Man, T., Petrea, D., Corpade, A.M. & Moldovan, C. (2014). *Changes in landscape structure induced by transportation projects in Cluj-Napoca periurban area using GIS*, Carpathian Journal of Earth and Environmental Sciences, Volume 4, No 9, Baia-Mare, Romania, pp. 177-184.

Corpade, C., Bădărău, Al. S., Corpade, Ana-Maria, Hognogi, Gh., Pop, Simona & Banc, Ștefana, 2016. *Changes in landscape metrics induced by deforestation in ROSCI0358 Pricop-Huta-Certeze Nature 2000 site.* STUDIA UBB GEOGRAPHIA, LXI, 2, 2016, pp. 53 – 61.

Corpade, C., Nicolin, Alma Lioara, Corpade, Ana-Maria & Arsene G.-G., 2016. Changes in the spatial structure of landscape within the site of community interest ROSCI0233 Someșul Rece. Research Journal of Agricultural Science, 48 (2), 2016

European Environmental Agency. (2006). The urban sprawl in Europe. The ignored challenge (EEA Report no.10/2006). Copenhagen, Denmark: European Environment Agency.

Fischer, J., & Lindenmayer, D. B. (2007). Landscape modification and habitat fragmentation: A synthesis. Global Ecology and Biogeography, 16(3), 265–280.

Leemans, R., 2013. *Ecological Systems*. Springer New York.

Li, X., He, H., Bu, R., Wen, Q., Chang, Y., Hu, Y. & Li, Y. 2005. *The Adequacy of Different Landscape Metrics for Various Landscape Patterns*. Pattern Recognition, 38: 2626 –2638.

Marcucci, D. J. (2000). Landscape history as a planning tool. Landscape and Urban Planning, 49(1–2), 67–81.

McGarigal, K. & Marks, B.J., 1994. *FRAGSTATS: Spatial pattern analysis program for quantifying landscape structure*. Reference manual. Forest Science Department, Oregon State University, Corvallis Oregon.62 #Appendix.

McGarigal, K. & Marks, B.J., 1995. *Spatial pattern analysis program for quantifying landscape structure*. General Technical Report PNW-GTR-351 US Department of Agriculture, Forest Service. Pacific Northwest Research Station.

McGarigal, K., Cushman, S.A., Neel, M.C. &Ene, E., 2002. *FRAGSTATS: spatial pattern analysis program for categorical maps*. Amherst: Computer software program produced by the authors at the University of Massachusetts. Available from http://www.umass.edu/landeco/research/fragstats/fragstats.html.

Niculae M.-I. & Pătroescu M., 2011, *Quantifying forest Ecosystems Fragmentation in the Subcarpathians between the Râmnicu Sărat and the Buzău Valleys, Romania, using Landscape Metrics*, Forum geografic. Studii și cercetări de geografie și protecția mediului, Volume 10, Issue 1, pp. 187-194.

Pătru-Stupariu, Ileana, Stupariu M. S., Cuculici, Roxana & Huzui, Alina. 2011. *Application of the global indicators to landscape change modeling on Prahova Valley (Romanian Carpathians and Subcarpathians).* International Journal of the Physical Sciences Vol. 6(3), pp. 534-539.

Schreiber W., Drăguț L. & Man T. (Eds.), 2003, *Analysis of the geographic landscape in the western part of the Transylvanian Plain*, Presa Universitară Clujeană, Cluj-Napoca, 135 p.

Turner, B. L., Lambin, E. F., & Reenberg, A. (2007). The emergence of land change science for global environmental change and sustainability. Proceedings of the National Academy of Sciences, 104(52), 20666–20671.

**** CORINE Land Cover data of 1990 and 2012 years - https://land.copernicus.eu/pan-european/corine-land-cover (Accessed August 2018)*

**** ANCPI, 2012. INIS Viewer. Romania Ortophotomaps Year 2012. National Agency of Cadastre and Real-Estate Publicity (Accessed September 2018).*

**** Statistic data of population and tourism flows from National Institute of Statistics, Romania (Accessed September 2018).*