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Assessment of the Impact of Population Reduction on Grasslands with a New "Tool": A Case Study on the "Mountainous Banat" Area of Romania

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Abstract: The landscapes and, implicitly, the surfaces of secondary grasslands in the mountain areas have been intensively modified and transformed by humans. In this context, this paper analyses the spatial and temporal changes of grassland surfaces following the impact of human population reduction. Thus, the study proposes the implementation of the Grassland Anthropic Impact Index (GAII) as a "measurement tool" to functionally link the two components, grassland surface and human population. The spatiotemporal analyses are based on Corine Land Cover data and demographic data, processed via Geographic Information Systems (GIS) methods and the Land Change Modeler (LCM) tool. The research shows that over a period of 28 years, the population, which was continuously decreasing, caused a series of transformations to the grasslands over an area of 33343 ha. The influence of the reduction in the number of inhabitants was also demonstrated by the direction of the changes produced in the grassland surfaces: in the better populated areas, the grasslands expanded over lands with other uses, and in the sparsely populated areas, they were abandoned. GAII values generally increase with the decrease of the population in the target area, meaning that for an inhabitant (potential user) a greater grassland surface is reported, resulting in a greater responsibility for the management of this resource on a space and time scale. Following the evaluation of the trend of the last 28 years, it was observed that the depopulation of mountain areas can be seen as a threat to grassland ecosystems, either through the transition to other categories of use, or through abandonment. The implications of these phenomena are much broader: they produce chain reactions and affect other components of the regional geosystem.

Keywords: Corine Land Cover; grasslands; agricultural land abandonment; human population; mountain landscapes; anthropogenic changes; risk assessment; Grassland Anthropic Impact Index; remote sensing

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1. Introduction

Grasslands represent the vegetation sward that provides the most valuable forage for animal breeding across all continents [1]. The physiognomy of secondary grassland habitats was determined by humans and their animals. The relationship between grasslands and the human population is long and complex. Modern humans are considered to have originated from the open pastures and savannahs of Africa, and these pastures generated the model

for the raw biological material that led to the development of modern agriculture and human society [2].

Following the development of human society, the natural environments where secondary (or semi-natural) grassland habitats have appeared and developed with their characteristic vegetation are continuously changing due to anthropic activity [3].

Grasslands have been intensely studied from numerous perspectives—natural, sociocultural, patrimonial, etc.—but not in such detail in terms of their relationship with the human population, which can generate production and consumption [4]. Grasslands are one of the main resources in the world's mountain areas, and human populations can influence, transform and provide dynamics to these natural resources.

A series of research highlights that about a tenth of the world's population lives in mountain areas [5], while they cover about a quarter of the terrestrial part of the globe [6–8]. According to a report produced by the European Parliament, mountain areas represent 40% of Europe's surface and are inhabited by 19% of the population of the continent [9], and the mountain area of Romania, delimited according to the National Rural Development Programme (NRDP) [10], represents 29.92% of the total surface of the country.

Mountain areas are vulnerable to global changes [11], but in the meantime contain water, forestry, food and energy resources and encapsulate about half of the world's biodiversity [12,13]. These are highly important elements of the sustainable development actions supported by international programmes (the Programme of the United Nations for Environment, the Programme of the United Nations for Human Development, etc.) through the mediation of governmental or nongovernmental agencies or national programmes [14–16].

In recent decades at the European level, rural areas and, implicitly, mountain areas have suffered intense demographic, socioeconomic, spatial and functional transformations [17–20] determined by agricultural policies, suburbanisation or the global market [21].

One of the main resources of mountain areas is agricultural land [22], but the literature indicates a trend of abandoning these lands over the last half century, which is occurring in many mountainous areas worldwide; this has led to the depreciation of environmental capital and negative consequences from a socioeconomic perspective [23]. Thus, dramatic changes in the structure of agriculture and land use systems can be noted, due to ecological, climatic and economic reasons which are creating pressure in mountainous areas [3]. In Western Europe, the abandonment of agricultural land [24] reflects a post-war trend of depopulation of "isolated" areas [25], and this phenomenon was also later noticed in Eastern Europe.

The agricultural landscape in the Romanian Carpathians, part of Eastern Europe, is mosaic-like, characterised by small arable land patches and large surfaces of forests and grasslands [26]. These areas are sometimes included in the list of lands with High Nature Value (HNV), according to the Common Agricultural Policy (CAP) of the EU, and in most cases they overlap with protected areas [27]. In Romania, mountain grasslands represent about 21% of the total surface area of about 4.9 million hectares [10]. About 15% of the total population of the country is concentrated in these areas [28]. These grasslands in mountainous areas are secondary (or semi-natural) in general, which is why they are dependent on human activity.

HNV grasslands across the entire Romanian mountain area feature great floristic biodiversity [29–32], provide a valuable habitat for a great number of species [33] and are still used extensively for traditional farming practices [34–36]. Users of HNV grasslands benefit from subsidies and compensations for the forage losses caused by the natural limitations of the grasslands' productivity and the extensive use systems applied, which they receive through agri-environmental and climate payments.

In recent years, the existence of geospatial datasets and specific techniques and applications for Geographic Information Systems (GIS) and remote sensing has allowed for complex analysis of human mobility, individual or collective [37,38], and analysis of the human population's "behaviour" in relation to different elements, such as physical–

geographical elements, socioeconomic processes, natural resources exploitation, risk situations, etc. [39–43]. On the basis of these geospatial data, migratory fluxes and territorial planning can be estimated [37], which have great importance in the process of sustainable development.

Analysis of land use changes using geomatic techniques for different aspects [44–49] has great importance, both for the components of the natural environment and from a socioeconomic point of view. The importance consists of the fact that it allows the evaluation of the current state, but also the evolution trends of the analysed territory. For this purpose, datasets can be used at a global level at different scales and spatial resolutions [50], such as Global Land Cover 2000 [51] and ESA GlobCover 2005 [52], but the low spatial resolution does not allow their use at a regional level. In this context, for a more detailed analysis and representation of the study area, the Corine Land Cover (CLC) database (https://land.copernicus.eu/en/products/corine-land-cover, accessed on 9 March 2023) was used, with an average spatial resolution of 25 m [53] generated by the processing of Landsat and Sentinel satellite images at the level of the European Union (EU), according to the literature [54]. The CLC database is a comprehensive land cover dataset that has been developed by the European Environment Agency (EEA). It provides information on land cover and land cover changes across Europe and is a good resource for studying the evolution of the grassland surface. Combining the demographic data with the CLC data can better emphasise the areas exposed to the risks of abandonment and can help decision-makers.

As a starting point for the research, the following hypothesis was formulated: in the case of any type of territory, the reduction or increase of the human population is reflected by the components of the natural environment. In this particular case, in the study area of Romania, there are secondary grasslands that were previously created as a result of deforestation, along with the expansion of human settlements and an increase in livestock necessary for human food. As such, these grasslands depend on and easily undergo transformations depending on human activity. Thus, the question arose: "*What is the impact of population reduction in the dynamics of grassland surfaces?*".

The objectives of this research were: (1) to analyse the spatial–temporal changes in two "instable" components of the mountain areas, specifically the grassland surfaces and the human population; on the basis of the obtained data, the transformations produced and their directions, in the case of the grasslands influenced by the diminishing human population, were quantified; (2) to apply a "measuring tool", the Grassland Anthropic Impact Index (GAII), as an index of the human capital that is able to manage the grasslands, in order to make a functional connection between those two components: grassland surface and human population of the territory.

From the results of these analyses, we are looking to raise awareness about the risk of depopulation in the mountain area of the studied territory, which is a phenomenon with direct and indirect implications on grassland habitats. On the basis of the Grassland Anthropic Impact Index (GAII), the available grassland surface for every active inhabitant (at active working age) was determined, and the regional disparities were highlighted, as well as the potential effects of the population decrease on the grassland use. This aspect is very important, because in the absence of the human management factor, grasslands are becoming vulnerable because of the encroachment of non-specific vegetation, quality and biodiversity degradation or reforestation, due to the succession trend of the terrestrial ecosystems that tend to return to their initial form.

Such studies have much wider implications, as population decline in most of the world's mountainous areas and the resulting implications represents a global issue, with different facets: landscape transformations, ecological implications, economic implications, etc. The need of this timely study is to assess the evolutionary trends of both grassland surfaces and the human component over a long period of time. On the basis of this assessment, local or regional management strategies or measures can be targeted to reduce negative social, economic or environmental impacts. The originality of the study lies in

the cumulative analysis, spatialised in the GIS environment, of the two factors taken into account and the implementation of the GAII index.

2. Materials and Methods

2.1. Study Area

The research presented in this work refers to the "Mountainous Banat" area, a region with historical references overlapping with the mountain areas in the southwest of Romania. The study area is complex from both a physical–geographical and socioeconomic point of view. There are relief formations on the analysed territory that belong to the Southern Carpathians [55], specifically the group Retezat-Godeanu (comprising the Mehedinți Mountains, Cernei Mountains, Godeanu Mountains and Țarcu Mountains) with altitudes greater than 2000 m, characterised by massiveness given by the crystalline shales and relief created by the quaternary glaciers [55], and on other side there are relief formations belonging to the Western Romanian Carpathians, specifically to the Banatului Mountains (comprising the Semenic-Almăj Mountains, Caraşului Mountains, Poiana Ruscă Mountains, Bistra-Timiş-Cerna Depression and Danube Gorge) characterised by lower altitudes (below 1500 m), petrographic mosaic, tectonic fragmenting and the presence of numerous intramountain depressions [56].

The study area is crossed by a parallel of 45° N (Figure 1), is about 143 km in length in the N-S direction (45°51′32.6″ N–44°35′7.0″ N, 22°24′15.5″ E–22°8′51.0″ E) and about 71 km in with in the W-E direction (45°19′57.7″ N–45°6′29.4″ N, 21°48′27.4″ E–22°39′23.8″ E).

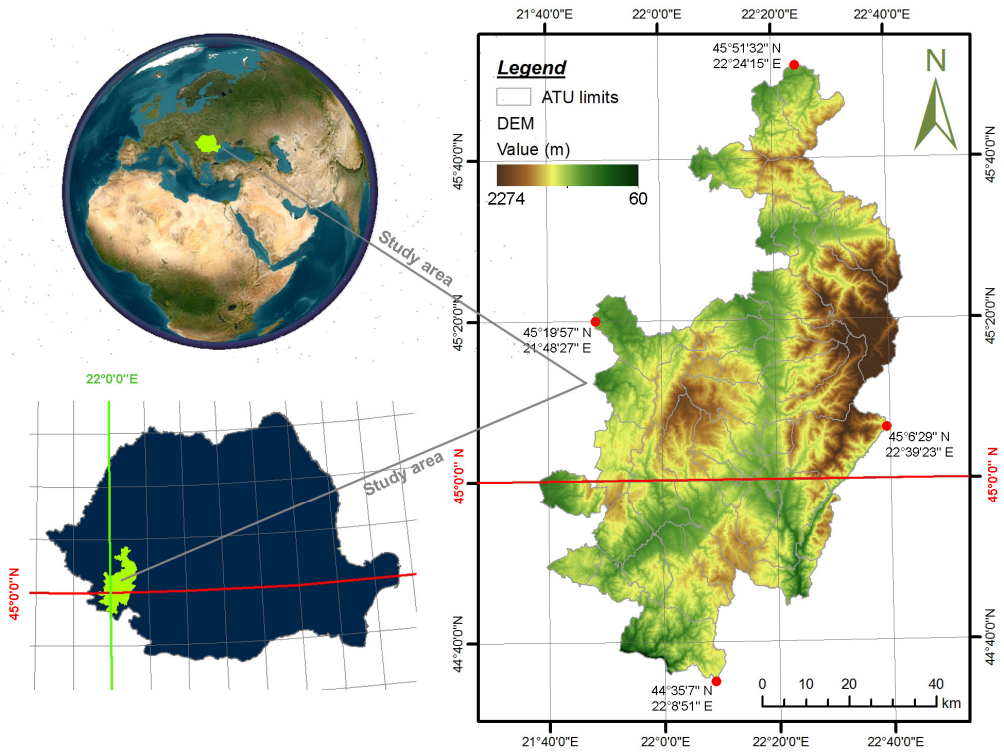


Figure 1. Localisation of the study area (designed by L. Copăcean using data from [10,28,57]).

The study area is expanded on an altitudinal interval between 60 and 2274 m a.s.l. (Figure 1), with an average altitude of 708 m. Climatically, it falls generally into the transition temperate continental climate with Mediterranean influence [56], with local particularities given by the geomorphological diversity.

Delimitation of the study area was carried out in accordance with the NRDP 2014–2020 [10], and included the communes (called Administrative Territorial Units—ATU) with an average altitude greater or equal to 600 m, or with an average altitude between 400 and 600 m and an average slope equal to or greater than 15%,

considered as components of the Romanian mountain area [10]. Th study area comprises 41 ATU with a total surface area of 562,000 ha (5620 km^2) and includes four cities and 173 rural localities. In the delimiting of the study area, the administrative–territorial criterion was chosen, in consideration of the fact that some of the data and scientific information used in this research are reported at ATU level.

Both by size and by historicopolitical references, the study area is representative for the Romanian Carpathians and for the Western Development Region of the country. The research and the results obtained are comparable with other mountain areas of Romania and mountains in Europe and beyond.

2.2. Used Data Sources

During the research, geospatial data were used referring to the land use, as were statistical data from the relevant institutions and descriptive data collected from observations in the field (assessment of the "physical" state of the grasslands and observations on the social and cultural phenomena).

For the analysis of the changes produced in land use mode, the Corine Land Cover (CLC) database from the years 1990, 2000, 2006, 2012 and 2018 was used, with data available for free on the platform Copernicus Land Monitoring Service [53]. Researchers of the current literature mention some anomalies in the structure of CLC datasets [58], which is the reason why in the present research the raw CLC databases were used instead of the datasets that show the analysis of changes (CHA). For the validation and correction of the coverage/use data of the lands, Google Earth images were used from the corresponding period, but they were overlapped with high spatial resolution images (orthophotoplans) and cadastre maps taken from the archive of the National Agency for Cadastre and Real Estate Advertising [59].

Analysis of the evolution of the number of the inhabitants and other demographic indicators was performed on the basis of the demographic maps, conceived on vectorial structures at ATU level [28], and for the physical–geographical characterisation of the area, a Digital Elevation Model (DEM) was used with the spatial resolution of 25 m [57].

Within the spatiotemporal analyses (1990–2018), several "thresholds" were defined (years 1990, 2000, 2006, 2012, 2018), initially selected according to two conditions: (1) to be common to the considered indicators (areas of grasslands and demographic data) so that there was the possibility of their correlation and (2) to be distributed as evenly as possible and over the entire analysed time interval, so as to cover the entire considered interval. The frequency of the data (thresholds) used in the research was set according to the available Corine Land Cover data, which also determined the final point of the analysis, that is the year 2018.

From the National Institute of Statistics (NIS) in Romania, data were taken at ATU level for the beforementioned temporal thresholds, referring to the total number of inhabitants, population structure by age groups, natality, mortality and migration [60]. On the basis of these data, the relevant demographic indicators were calculated.

The spatialisation and analysis of the data, as well as the generation of the cartographic materials, was carried out with the software ArcGIS 10.4 [61] and TerrSet 18.21 [62].

2.3. Classification of the Land Use Mode

In the present study, land cover/land use data were extracted from CLC datasets with a 25 m spatial resolution, generated by processing Landsat and Sentinel satellite imagery. The database, developed by the EEA for Europe, is a good resource for studying the evolution of grassland surfaces.

In the case of the study area, in accordance with CLC, 29 classes of land use were identified. For practical reasons those 29 classes were reclassified according to Table 1. Thus, 12 classes were obtained that define the main uses of the land in the study area and which are used in all the analyses performed in the present paper.

Table 1. Reclassification of Corine Land Cover databases.

Land Use Classes	CLC Code of the Year					Reclassify	
	1990	2000	2006	2012	2018		
Discontinuous urban fabric	112	112	112	112	112	1	Built space
Industrial or commercial units	121	121	121	121	121	2	Areas with human activities
Road and rail networks and associated land	122	122	122	122	122		
Port areas	123	123	123	123	123		
Airports	124	124	124	124	124		
Mineral extraction sites	131	131	131	131	131		
Dump sites	132	132	132	132	132		
Construction sites	133	133	-	133	133		
Green urban areas	141	141	-	141	141		
Sport and leisure facilities	142	142	142	142	142		
Non-irrigated arable land	211	211	211	211	211	3	Arable land
Vineyards	221	221	221	221	221	4	Vineyards
Fruit trees and berry plantations	222	222	222	222	222	5	Fruit trees
Natural grasslands	321	321	321	321	321	6	Grasslands
Pastures	231	231	231	231	231		
Complex cultivation patterns	242	242	242	242	242	7	Complex cultivation patterns
Land principally occupied by agriculture, with significant areas of natural vegetation	243	243	243	243	243	8	Agricultural land with natural vegetation
Broad-leaved forest	311	311	311	311	311	9	Forest areas
Coniferous forest	312	312	312	312	312		
Mixed forest	313	313	313	313	313		
Moors and heathland	322	322	322	322	322	10	Shrub vegetation
Transitional woodland-shrub	324	324	324	324	324		
Beaches, dunes, sands	331	331	331	-	-	11	Non-vegetated areas
Bare rocks	332	332	332	332	332		
Sparsely vegetated areas	333	333	333	333	333		
Inland marshes	411	411	411	411	411	12	Water surfaces
Water courses	511	511	511	511	511		
Water bodies	512	512	512	512	512		

2.4. Working Flow

2.4.1. Analysis of the Changes in the Land Uses and in the Grassland Surfaces

The analysis of the land use and grassland surface changes were performed in the following phases (Figure 2):

a. Analysis of the spatial distribution and general quantitative analysis of the changes produced in the land use were performed in the GIS environment on the basis of CLC data from every temporal threshold, and the results outline the overall situation and the general trends of the changes produced in the land use, and implicitly in the type of vegetation in the study area;

b. Analysis of the changes in grassland surfaces on temporal thresholds using the Land Change Modeler (LCM), implemented in the TerrSet 18.21 software [62], which is usually used in assessments and environmental prognoses or in sustainable development strategies [47,63,64]; the net changes and the contribution to changes in the case of the grasslands in the area of interest were analysed;

c. Detailed analysis of the changes from the period 1990–2018, based on the CLC database from the beginning and end of the considered interval, was performed on the basis of the transitions matrix obtained through the spatial intersection of the two datasets in ArcGIS; in the case of the grasslands, surface gains and losses, net changes and contributions to changes were quantified; in the LCM module, the data were spatialised in the form of a map of the changes and a map of the transitions to identify their distribution and territorial disparities.

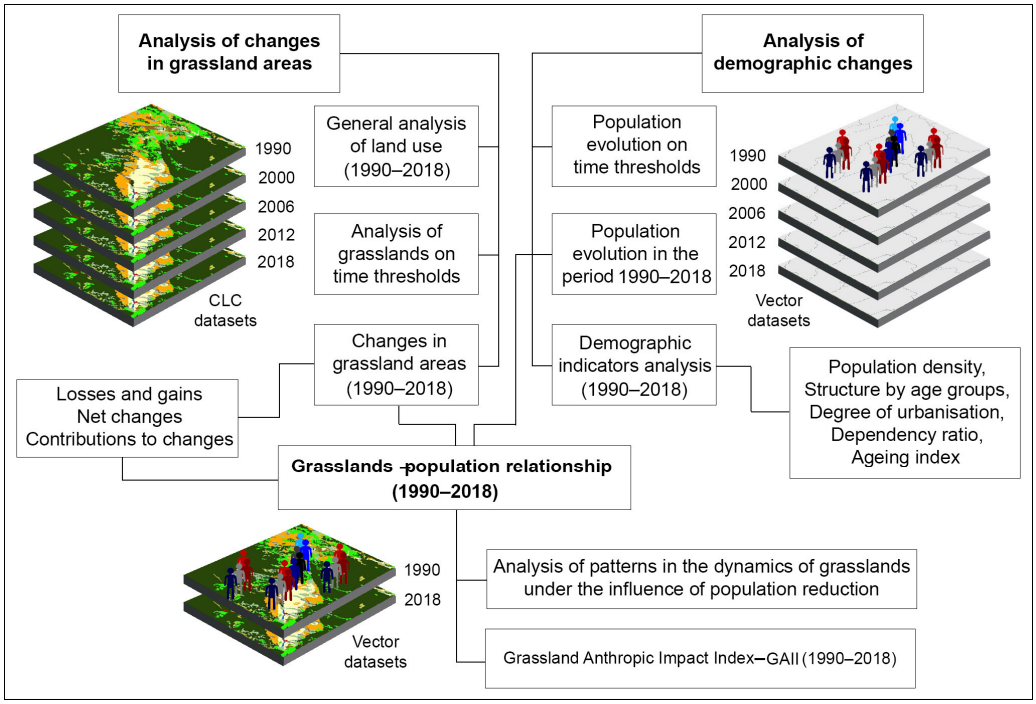


Figure 2. Workflow (designed by L. Copăcean).

2.4.2. Analysis of the Evolution of the Number of Inhabitants and Relevant Demographic Indicators

The analysis was performed on the interval 1990–2018, but also on temporal thresholds, in order to analyse the general evolution of the demographic indicators, but also the trends within the interval. On the basis of the demographic maps, the territorial distribution of demographic indicators was analysed. The purpose of these analyses was to identify the demographic phenomena and trends from the interest area and to later quantify the human resource of this territory. The situation was analysed at the level of the entire area but also at ATU level.

The demographic analysis had in view many essential aspects for the characterisation of the population of a territory: numeric evolution of the population, population density (Relation 1) [65], urbanisation degree, structure of age groups, report of demographic dependence (Relation 2) [65] and demographic ageing index (Relation 3) [66]. For the calculation of these indicators, the formulae in Table 2 were applied.

Table 2. Demographic indicators used in the study.

Indicator	Calculation Formula	
Population Density (Number of People/km^2)	Number of People/Area	Relation 1
Report of demographic dependence (per 100 inhabitants)	[(Population under 15 years + Population over 65 years)/(Population between 15 and 64 years)] × 100	Relation 2
Demographic ageing index (per 100 inhabitants)	(Population over 65 years/Population under 15 years) × 100	Relation 3

2.4.3. Analysis of the Relationship between Grassland Surface and Population during 1990–2018

The analysis took into consideration two aspects:

a. Evaluation of the impact of the population reduction on the directions of changes in grassland surfaces; in this case, the study area was split into five subareas, depending on the variation rate of the number of inhabitants. For each subarea, the grassland surface at the beginning and end of the interval, surface gains and losses and net changes were calculated; thus, the participation of other land use classes in the changes produced in the grassland class was determined (the share of the total changes in each subarea). Through this analysis type, the directions of the changes experienced by the grassland surface following the impact of the reduction in the number of inhabitants were established.
b. Evaluation of the grassland surface based on Grassland Anthropic Impact Index (GAII), in accordance with the formula (original method):

Grassland Anthropic Impact Index (GAII) (ha/inhabitant)	GAII = Grassland surface/number of inhabitants	Relation 4

The GAII index formula, which is the ratio of the area of grassland (ha) in a given territory to the number of inhabitants living in that territory. It is expressed in ha/inhabitant. This index monitors the "quantity" of grassland per inhabitant and highlights the potential for its use. The minimum values of the GAII (close to 0) indicate that a small area of grassland is allocated to a resident, while the maximum values suggest a large area of grassland (in the case of this study, more than 13 ha/resident) that has been allocated to a resident.

In the calculation of GAII, initially the surface of the grassland was reported to the total number of inhabitants (GAIIt), but later it was reported to the number of active inhabitants aged between 15 and 64 years (GAIIa); in this way, the grassland surface was determined which is attributed to every inhabitant of working age (ha/active inhabitant) who can be considered as a "user" of the grassland resources. The data resulting after the application of GAII were spatialised at the level of ATU for the two considered reference years (1990 and 2018); in this way, it was possible to evaluate the changes produced and identify the territorial disparities.

3. Results

The study area comprises a great diversity of the relief forms and units that is reflected in the land use too, and implicitly in the vegetation distribution and typology. It is composed of 41 ATU (38 in the territory of Caraş-Severin County and three in Timiş County) and includes four towns (Reşiţa, Băile Herculane, Oţelu Roşu and Anina) and 173 rural localities; it represents 2.35% of the surface of the country and 7.87% of the surface of the Romanian mountain area [10,28,60].

3.1. Changes in the Land Use during the Period 1990–2018

3.1.1. Spatial–Temporal Distribution of the Land Use Classes

According to Figure 3, in the land fund of the study area, forest areas (deciduous forests, mixed forests and coniferous forests) dominate in all the analysed years. In the case of the mountains with low altitudes (Almăjului Mountains, Poiana Ruscă Mountains, Aninei Mountains, etc.), the forests are present from the base to their upper area. In the case of the higher mountains (Ţarcu Mountains and Godeanu Mountains), the forests are layered up to around the altitude of 1600 m (the superior limit of the forest), followed by the alpine gap dominated by alpine grasslands, shrubby vegetation (dwarf mountain pine and juniper) and rocky vegetation. In the interior and at the outer limit of the forests are positioned the lands with shrubby vegetation.

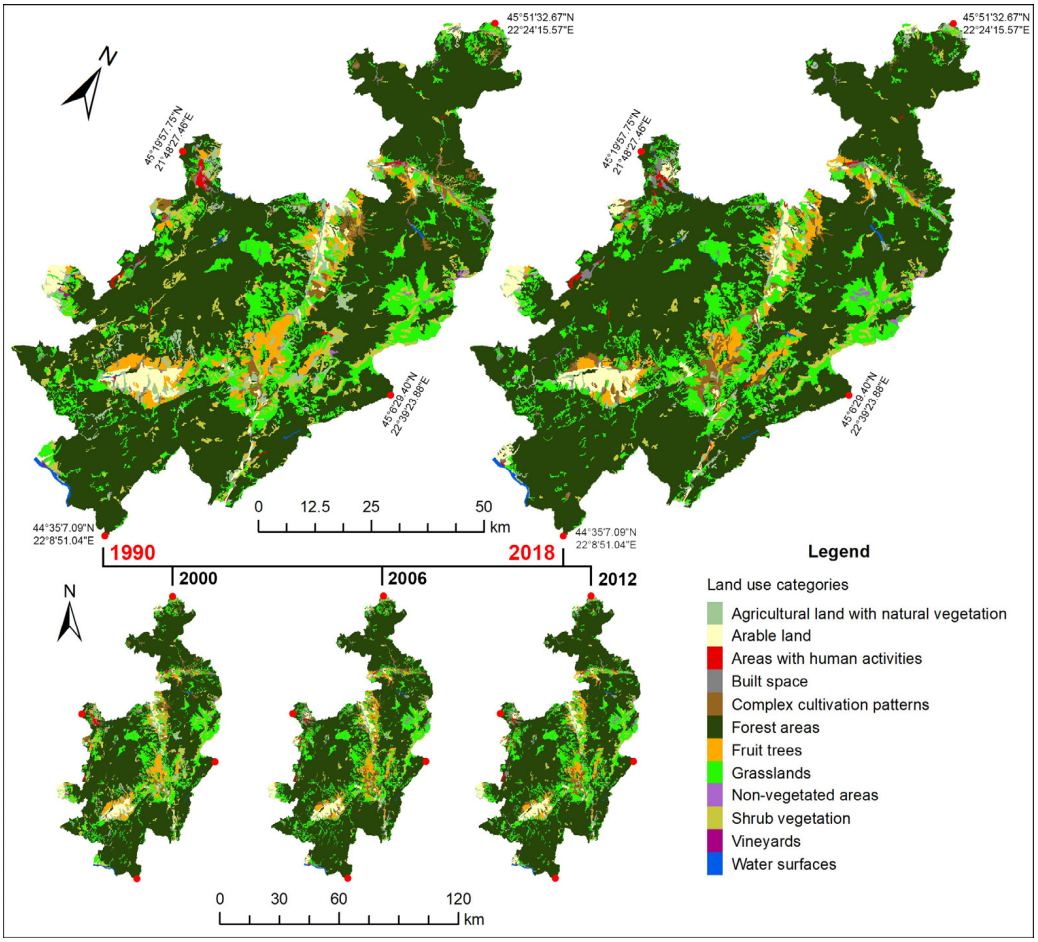


Figure 3. Spatial–temporal distribution of the land use classes during the period 1990–2018 and the evolution of the grassland surfaces in the study area (processed using data from [28,53]). (The use categories in the legend correspond to the reclassified codes in Table 1).

Grasslands are present in all the relief forms and units of the high mountain area located inside the forest areas, and as transition areas between forests and other land use classes, as well as at low altitudes in intramountain depressions, where they are interposed mainly with agricultural land. In the central part of the study area (Timiş-Cerna pass, Bistrei pass and Bozovici Depression), the depressions that separate the main mountain groups, they dominate the agricultural land use (arable land, complex crops areas, orchards, etc.) on small surfaces and mosaic-like and fragmented surfaces because they belong to different land owners. Specific to the organisation of the territory in the mountain areas, human settlements are located in the depression areas or along the river valleys.

3.1.2. Analysis of the Changes, Referring in Detail to the Grassland Surfaces

Analysis of the changes, mainly the dynamics of the grassland surfaces in the study area, was expressed in several forms: quantitatively and as percentages; by net surface changes on temporal thresholds (Table 3); as contributions to changes through the matrix of the land use transitions for the entire analysed time interval (Table 4). In the case of grassland surfaces, a map was generated with the localisation of the changes (respectively losses, gains and unchanged surfaces) and the map with the spatial distribution of the surfaces that have contributed to changes in the grassland land use classes (transitions map).

Table 3. Changes of the land use classes and their share during the time interval 1990–2018.

Land Use	Area 1990		Area 2000		Area 2006		Area 2012		Area 2018	
	ha	%	ha	%	ha	%	ha	%	ha	%
Built space	6768	1.20	6768	1.20	6003	1.07	6429	1.14	6429	1.14
Shrub vegetation	32,956	5.86	27,783	4.94	14,068	2.50	13,975	2.49	14,485	2.58
Non-vegetated areas	738	0.13	738	0.13	1230	0.22	1200	0.21	1200	0.21
Water surfaces	1487	0.26	1485	0.26	1631	0.29	1480	0.26	1480	0.26
Areas with human activities	2117	0.38	2117	0.38	1103	0.20	1252	0.22	1254	0.22
Arable land	15,876	2.82	15,877	2.83	19,092	3.40	19,046	3.39	19,046	3.39
Vineyards	240	0.04	240	0.04	50	0.01	64	0.01	64	0.01
Fruit trees	22,731	4.04	22,731	4.04	20,885	3.72	17,262	3.07	17,262	3.07
Grasslands	**77,164**	**13.73**	**77,096**	**13.72**	**78,435**	**13.96**	**82,106**	**14.61**	**82,104**	**14.61**
Complex cultivation patterns	9621	1.71	9622	1.71	15,477	2.75	13,035	2.32	13,035	2.32
Agricultural land with natural vegetation	17,981	3.20	17,981	3.20	13,322	2.37	11,999	2.14	11,999	2.14
Forest areas	374,322	66.61	379,563	67.54	390,704	69.52	394,153	70.13	393,643	70.04

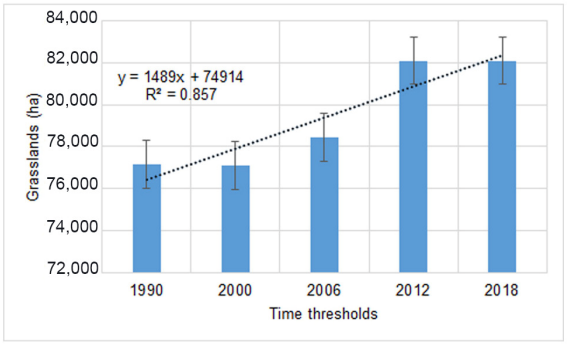
Table 4. Matrix of the transitions of the land uses during the time interval 1990–2018 (ha).

1990/2018	A	B	C	D	E	F	G	H	I	J	K	L	Total 1990
A		2345	19	12	2851	1707	831	**5514**	3	60	4	30	17,981
B	268		29	44	635	141	185	**627**	0	123	11	0	15,876
C	71	14		575	123	336	1	**16**	0	14	0	45	2117
D	474	76	73		425	296	95	**187**	0	4	2	12	6768
E	838	943	0	133		609	1498	**1746**	0	216	0	39	9621
F	358	108	77	135	128		156	**1940**	34	3300	0	94	374,322
G	1097	224	0	32	3214	1174		**4110**	0	57	0	0	22,731
H	**2448**	**1019**	**15**	**345**	**978**	**7931**	**595**		**160**	**695**	**0**	**18**	**77,164**
I	0	0	0	0	0	68	0	**153**		73	0	13	738
J	1673	492	103	26	1061	13,252	1075	**4750**	570		0	45	32,956
K	44	0	0	2	0	83	0	**63**	0	0		0	240
L	123	10	17	0	15	60	0	**45**	0	31	0		1487
Total 2018	11,999	19,046	1254	6429	13,035	393,643	17,262	**82,104**	1200	14,485	64	1480	562,001

Legend: A—Agricultural land with natural vegetation; B—Arable land; C—Areas with human activities; D—Built space; E—Complex cultivation patterns; F—Forest areas; G – Fruit trees; H—Grasslands; I—Non-vegetated areas; J—Shrub vegetation; K—Vineyards; L—Water surfaces.

The data presented in Table 3 show the fact that forests and grasslands were covering between 80 and 85% of the analysed area during all the analysed years. Changes in the structure of the land fund were observed especially after the year 2006 on the background of the legislative changes and the implementation of the policies designated for the revival of the agricultural sector, once with the accession and entry of Romania into the EU.

During the analysed time period, the surfaces used as grasslands increased by 6.40% (4944 ha), with a significant change observed after the year 2006 (Figure 4). Thus, in the year 1990 they covered 77,164 ha (13.73%) of the total surface of the study area, and after 28 years they were spread over 82,104 ha (14.61% of the total analysed area) despite all the economic, agrarian and political–administrative changes (Table 3).



2000	2006	2012	2018	Time thresholds	2000	2006	2012	2018
−64	1338	3672	−2	Net changes	−64	1338	3672	−2
−				Land use categories	+			
−1		−349		A		123		
		−35	−2	B		11		
	−457			C	2		39	
				D		51		
				E		958	2656	
				F				
	−896			G			2573	
				H		942	1486	
	−2926	−2925		I	2			
−66				J		3547	234	
−1	−8			K				
	−7	−7		L				
−68	−4294	−3316	−2	Losses/Gains	4	5632	6988	0

Figure 4. Net changes and the contribution to the change of the grassland surfaces by time thresholds during the time interval 1990–2018. Legend: A—Built space; B—Areas with human activities; C—Arable land; D—Vineyards; E—Fruit trees; F—Grasslands; G—Complex cultivation patterns; H—Agricultural land with natural vegetation; I—Forest areas; J—Shrub vegetation; K—Non-vegetated areas; L—Water surfaces.

The detailed analysis of the changes using the instrument LCM allows the establishing of the contribution of other land use classes to the dynamics of the grassland surfaces, depending on the temporal thresholds (Figure 4).

Major changes were noticed during the period 2006–2012, on one hand in the reforestation of some lands used as grasslands (5991 ha), and on the other hand in the reclamation of some grassland surfaces from the lands with shrubby vegetation (3547 ha), orchards (2656 ha), lands with complex crops (2573 ha) and agricultural lands with natural vegetation (1486 ha).

In light of the fact that in this research analysed the changes during the time interval 1990–2018, below the data will be considered from the beginning and end of this time interval.

In the analysed interval, especially in the mountain area, a net increase in the forest areas was noted (19,321 ha, 5%), mainly through two mechanisms: the transition of the areas with shrubby vegetation into forest (13,252 ha) and the afforestation of the grasslands (7931 ha) (Table 4). This situation can be explained on the one hand as a result of the restriction of deforestation, and on the other hand as a result of the population reduction and, therefore, of the decrease of the population's interest in agricultural activities.

On the other hand, 3300 ha of the forest areas were converted into land with shrubby vegetation and 1940 ha displayed deforestation and grasslands in the areas where the expansion of the pastoral area was intended, with a view to produce agricultural exploitation.

Thus, the net increase of the surface of the arable lands was noted as 3170 ha (20%) in the depressionary areas, populated on the back of the financial "incentives" granted to agriculture, and achieved by clearing land with natural vegetation (2345 ha), converting the grasslands into arable land (1019 ha) or converting the lands with complex crops (943 ha). On the contrary, some arable land was turned into land with complex crops (635 ha) or abandoned and transformed over time into grasslands (627 ha).

Although fruit growing represented one of the economic activities of the population of the area, the areas used for fruit tree plantations decreased by 5469 ha (24%) as a result of the change in the profile of agricultural activities in the area after 2006, with different transformations depending on the component subareas.

Through the spatial intersection of the two data sets from 1990 and 2018 (Table 3), in the case of the grasslands it was established that their surface had a net increase of 4944 ha, resulting from the addition of 19,144 ha in some areas and the loss of 14,200 ha in other areas (Figure 5). As a result, at the level of study area, in time and space, 33,343 ha of grassland were "mobilized". In other words, at the level of the year 2018, compared to 1990, 62,960 ha of the 82,104 ha of grasslands were not affected by changes, 19,144 ha passed into the category of grasslands from lands with other uses, and 14,200 ha were lost by moving to other categories.

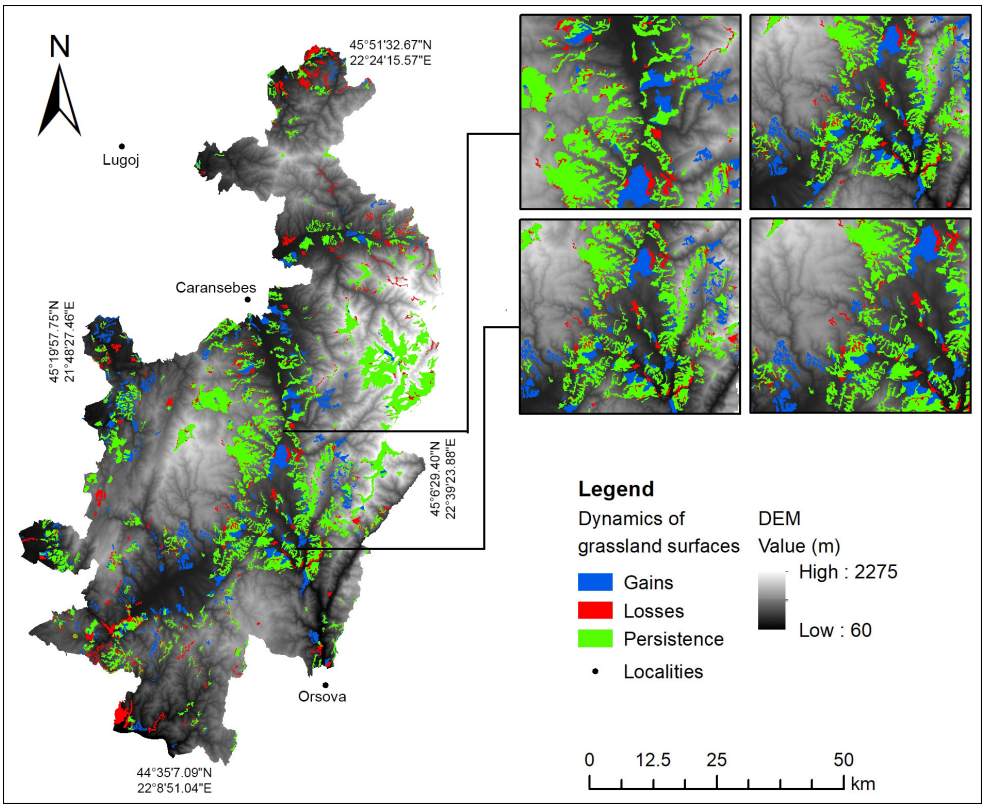


Figure 5. Map of the grassland surface losses and gains during the time interval 1990–2018 (processed using data from [28,53,57]).

Loss of the grassland surfaces has occurred mostly due to (Table 4):

a. Transition to the category of forest for 7931 ha (56% of the total of the lost surfaces), which is a phenomenon encountered at the point of contact with the forest and pastoral areas, found across the entire analysed area (Figure 6), but especially in the Semenic Mountains, Poiana Ruscă Mountains and Almăjului Mountains;
b. Transition to the category of the agricultural lands with natural vegetation for 2448 ha (17% of the total of the lost surfaces) in the areas with lower altitudes; and to the category of the lands with shrubby vegetation for 695 ha (5% of the total of the lost surfaces) in the areas with higher altitudes (Figure 6); these phenomena represent the early stages of grassland afforestation due to their underexploitation or abandonment;
c. Conversion of 1019 ha into arable land (7% of the total of the lost surfaces) occurred in depression areas (Figure 6) with higher population densities; in these areas focused on subsistence agriculture, exploitation of the land as arable land aims to obtain basic products (cereals, vegetables and fruits); the situation is similar in the case of the transformation of the grasslands into complex crops (7% of the total lost areas).

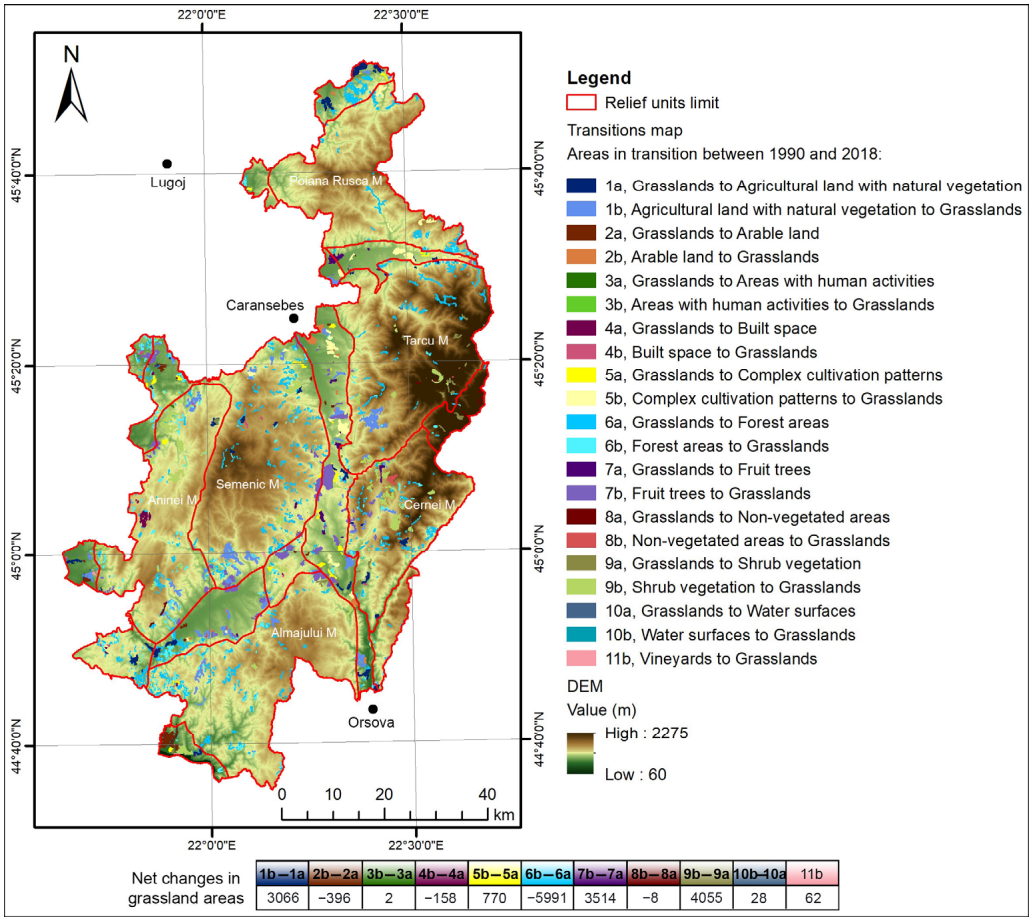


Figure 6. The location of the surfaces in transition from and into the category of grasslands (processed using data from [28,53,57]).

The expansion of the grassland surfaces occurred mostly through the transition of some areas from the following categories of land use (Table 4):

a. Agricultural land with natural vegetation across 5514 ha (29% of the total gained areas); the transformation took place in the depressionary area and the low hills as a result of the "cleaning" of those lands in order for them to be used for grazing and hay cutting; the situation is similar in the case of lands with complex crops (Figure 6);
b. Lands with shrubby vegetation across 4750 ha (25% of the total gained areas); the transformation took place mostly in the low mountain area, where it was desired to expand the areas of grasslands by removing the shrubby vegetation;
c. Orchards on 4110 ha (21% of the total gained areas); the phenomenon occurred in depressionary areas and highlights the abandonment of fruit processing and marketing activities, one of the traditional occupations from the study area; a "reconversion" was noted towards the exploitation of agricultural land and animal husbandry.

3.2. Analysis of the Human Component during the Period 1990–2018

For the area considered in the present case study, in the analysis of the numeric evolution of the population and of the demographic indicators, the time interval 1990–2018 and the temporal thresholds for the analysis of the grassland surfaces were maintained, and in this way the data could be compared.

3.2.1. Analysis of the Evolution of the Number of Inhabitants

In the period 1990–2000, of the 41 ATUs analysed, 70.73% recorded population losses between 0 and 9.9%, and 26.83% have lost between 10.0 and 19.9% of the population. The

increase in the number of inhabitants by 0.51% was registered only in ATU Oţelu Roşu (Figure 7).

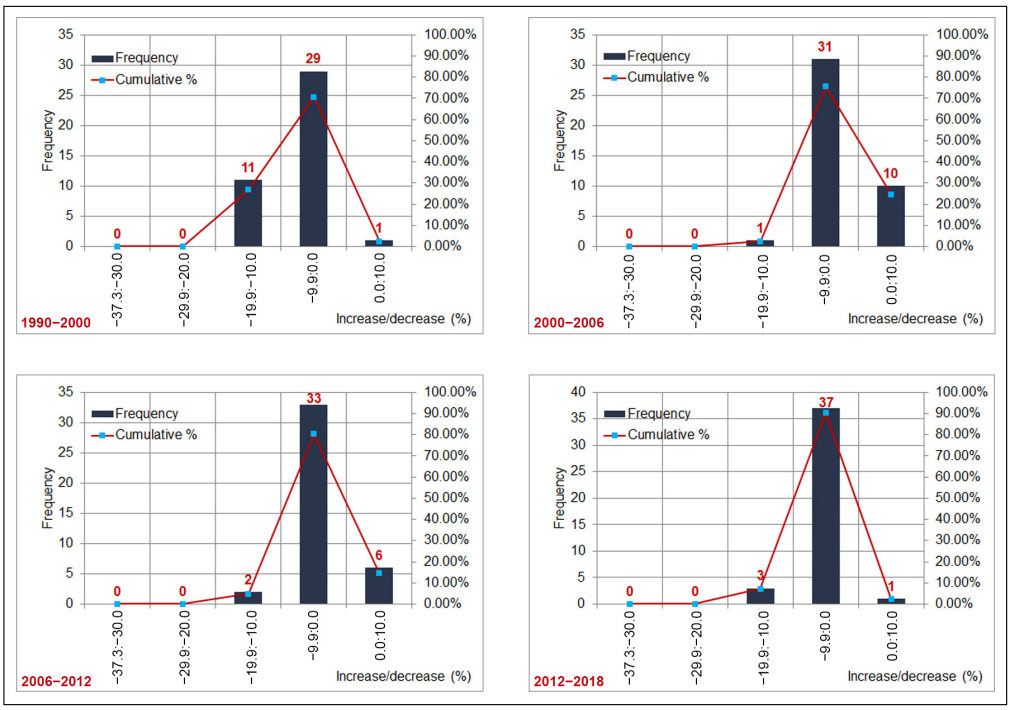


Figure 7. Regional aspects regarding increase/decrease in the relative percentage of the number of inhabitants at ATU level at different time intervals (processed using data from [60]).

During the interval 2000–2006, in 10 of the 41 ATUs there was an increase in the population, with a rate between 0.0 and 10.0%. In the other localities, the downward trend was maintained and the largest population reduction was noted in the case of the locality Şopotu Nou (Figure 7).

In the time interval 2006–2012, there were registered increases of the population in 6 ATUs; however, the rate of population decline was accentuated for most of the analysed localities (Figure 7). The greatest reductions in the population were noticed in ATU Cărbunari (14.20%).

In the following analysed period 2012–2018, the number of inhabitants increased in only one ATU (Turnu Ruieni) by 0.17%. In about 90% of the analysed ATUs, a diminishing of the population was registered, at rates between 0.0 and 9.9%.

Analysing the evolution on temporal thresholds, the continuous reduction in the number of inhabitants is found in most of the analysed cases.

In general, at the level of the entire analysed area and time interval (1990–2018), the number of inhabitants was reduced with 15.50%, and this percentage represents 34,939 persons. If in 1990, 225,385 inhabitants were registered, in 2018 their number was reduced to 190,446 inhabitants.

A more detailed analysis shows the existence of significant territorial disparities (Figure 8). The relative percentual rate of population variation was between 6.5% (population increase in 37—Brebu Nou) and −37.39% (population reduction in 7—Şopotu Nou).

The greatest population losses were noted in the localities 7—Şopotu Nou, 31—Mehadica, 11—Cărbunari and 20—Lăpuşnicel, with a diminishing rate of between 30 and 40% in the isolated areas that are difficult to access or considered "dead" areas due to the cessation of the industrial activities. From all the analysed ATUs, 36.58% (15 ATUs) have lost between 20.0 and 29.9% of the total number of inhabitants, and other 15 ATUs have registered a reduction in the population of 10.0–19.9%. In five ATUs, the population has decreased at a rate of 0.0–9.9%, and

the number of inhabitants increased by 0.59% in 2—Glimboca ATU and 6.45% in 37—Brebu Nou ATU, generally due to the development of the touristic activities.

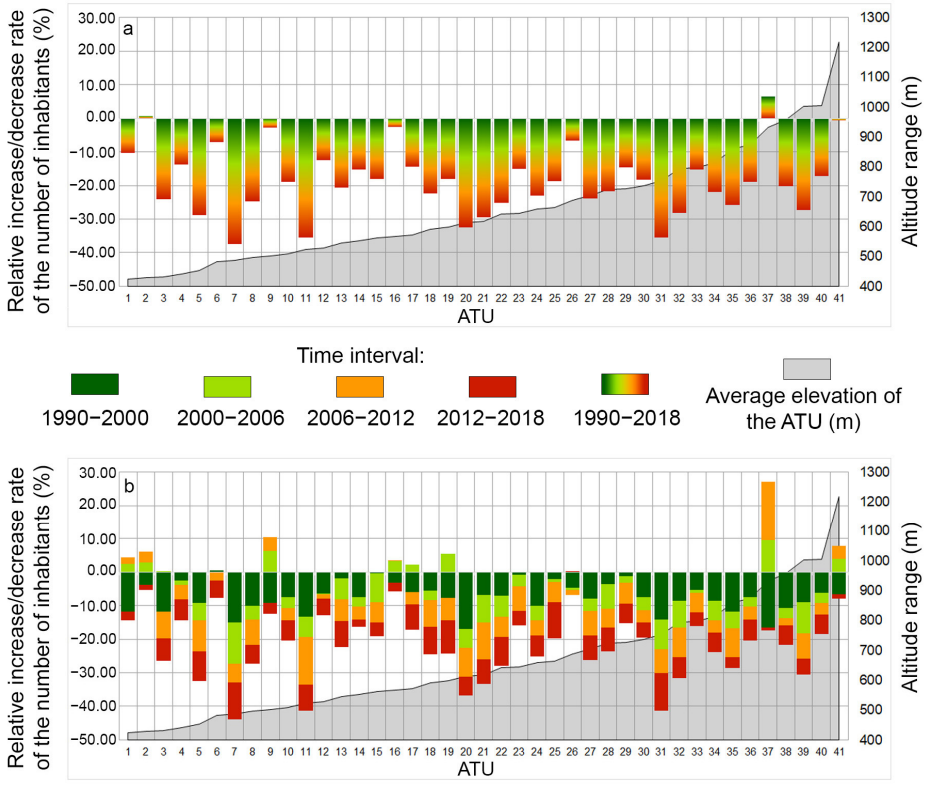


Figure 8. Representation of ATUs depending on the increase/decrease relative rate in the number of inhabitatnts during 1990–2018 (**a**) and on temporal intervals (**b**) (processed after [60]). The numbers represent: 1—Ciclova Romana; 2—Glimboca; 3—Berzasca; 4—Resita; 5—Cornea; 6—Otelu Rosu; 7—Sopotu Nou; 8—Dalboset; 9—çBuchin; 10—Carasova; 11—Carbunari; 12—Toplet; 13—Lapusnicu Mare; 14—Bucosnita; 15—Nadrag; 16—Mehadia; 17—Bozovici; 18—Iablanita; 19—Bania; 20—Lapusnicel; 21—Tomesti; 22—Luncavita; 23—Pietroasa; 24—Domasnea; 25—Baile Herculane; 26—Turnu Ruieni; 27—Marga; 28—Eftimie Murgu; 29—Anina; 30—Slatina Timis; 31—Mehadica; 32—Prigor; 33—Rusca Montana; 34—Armenis; 35—Valiug; 36—Bolvasnita; 37—Brebu Nou; 38—Bautar; 39—Cornereva; 40—Teregova; 41—Zavoi.

The number of inhabitants has a general descending trend in most of the analysed ATUs reported to the population in 1990 (Figure 8).

Relief, expressed by altitude, was not manifested as a determinant factor in the reduction of the population (Figure 8), keeping in mind the expansion of the ATUs on a great altitudinal level. Furthermore, the population reduction rate was not dependent on the defined temporal intervals in the case of the analysed ATUs.

3.2.2. Analysis of the Changes Based on Demographic Indicators

Once the number of inhabitants was reduced, the population density values fell from 40.10 inhabitants/km^2 in the year 1990 to 33.89 inhabitants/km^2 in the year 2018 (Table 5).

In accordance with the general principles of population distribution on altitude, with respect to our study area, the population density was minimal in high mountain areas and maximal in urban areas or at low altitudes, in valleys or depressions. The smallest values of the density of the population were registered in the Pietroasa and Mehadica ATUs, below 10 inhabitants/km^2, and the greatest values in the towns Reşiţa (437.46 inhabitants/km^2) and Oţelu Roşu (203.06 inhabitants/km^2).

The urbanisation degree was 57.97% in 1990 and 59.0% in 2018 (Table 5); at the level of the entire region, this value was greater in comparison with the national average of 54.75%

in 2016, explained by the fact that the population of declining rural settlements migrated to the cities from the region.

Table 5. Demographic characteristics of the study area (processed using data from [60]).

Demographic Indicators		1990	2000	2006	2012	2018
Number of inhabitants		225,385	215,475	211,491	202,324	190,446
Density of the population (inhabitants/km^2)		40.10	38.34	37.63	36.00	33.89
Urbanisation degree (%)		57.97	59.32	59.74	59.72	59.45
Population structure by age (% of total)	0–14	21.67	17.71	14.39	13.43	12.19
	15–64	67.89	69.88	71.33	71.50	69.91
	65+	10.43	12.41	14.29	15.07	17.90
Report of demographic dependence (per 100 inhabitants)		47.29	43.11	40.20	39.85	43.05
Index of demographic ageing (per 100 inhabitants)		48.14	70.10	99.31	112.26	146.80

The demographic dependence report at the level of study area registers lower values in comparison with the values reported at the national level, specifically 50.05/100 inhabitants [67]. This report shows that 100 of people of working age are associated with more than 39.85 dependent people (Table 5) in all the analysed cases. The generations born after 1990 are smaller in size, will be active on the labour market in the years 2020–2030 and will have to support a large and economically inactive elderly population.

In the year 1990, 100 people of working age were associated 10.43 people aged 65 and over; in the year 2002, their number increased to 12.41 people from the same category; in 2018, this report increased to 17.90 elderly persons associated with 100 people of working age. The economic burden of the adult population, comprising the generations born in the last twenty years, will became more than double. Thus, an imbalance was created, with a great risk of increasing in the future between the segment of the population with potential as taxpayers and the potential beneficiaries [68]. In the same context, the registered values show a decrease in natality, with the population under the age of 14 decreasing from 21.67% in the year 1990 to 12.19% in the year 2018.

The values of demographic ageing index, which shows the increase in the rate of the elderly population and diminishing in the rate of the young population [69], characterises the analysed territory as an aged population area. Rising from the value of 48.14 elderly persons per 100 inhabitants, after the year 2000 this reached the value of 70.10 elderly persons per 100 inhabitants; this process continued in an alarming way, and thus in the year 2018, the value of 146.80 elderly persons per 100 inhabitants was reached (Table 5). The situation is alarming at the level of the entire country, which displays values of 114.34 elderly persons per 100 inhabitants [67], but the great problem is the fact that once a mountain area has been depopulated, it is very difficult to repopulate it with inhabitants from other areas who are willing to assume all the current functions of the mountain households [4].

3.3. Quantification of the Transformations of Grassland Surfaces under the Influence of the Human Factor during the Period 1990–2018

The analysis of the two variables, the human factor and the grasslands in the interest area, referred to two aspects: (1) the evaluation of the influence of the anthropic factor, as a result of the variation in the number of inhabitants, according to the nature of the transformations that took place in the spatial–temporal "behaviour" of the grasslands, specifically the direction of the changes produced and (2) the evaluation of the quantitative changes, achieved by applying the Grassland Anthropic Impact Index (GAII).

3.3.1. Evaluation of the Impact of Population Reduction on the Behavioural Pattern of the Grassland Surfaces

According to the data presented previously, for the time interval 1990–2018, first the changes to the spatial–temporal distribution of the land surfaces used as grasslands were highlighted, and second the continuous diminishing of the number of inhabitants in most of the analysed cases, and the descending trajectory of other demographic indicators that suggest the ageing of the population. In this context, the "behaviour" was analysed in time and space of the land surfaces used as grasslands in relation to the reduction in the number of inhabitants. According to the working methodology, the 41 analysed ATUs in the study area were grouped into five subareas (noted from A to E), established according to the population reduction rate (Figure 9), registered at the end of the analysed time interval in the year 2018 in comparison to the beginning of the research interval, the year 1990.

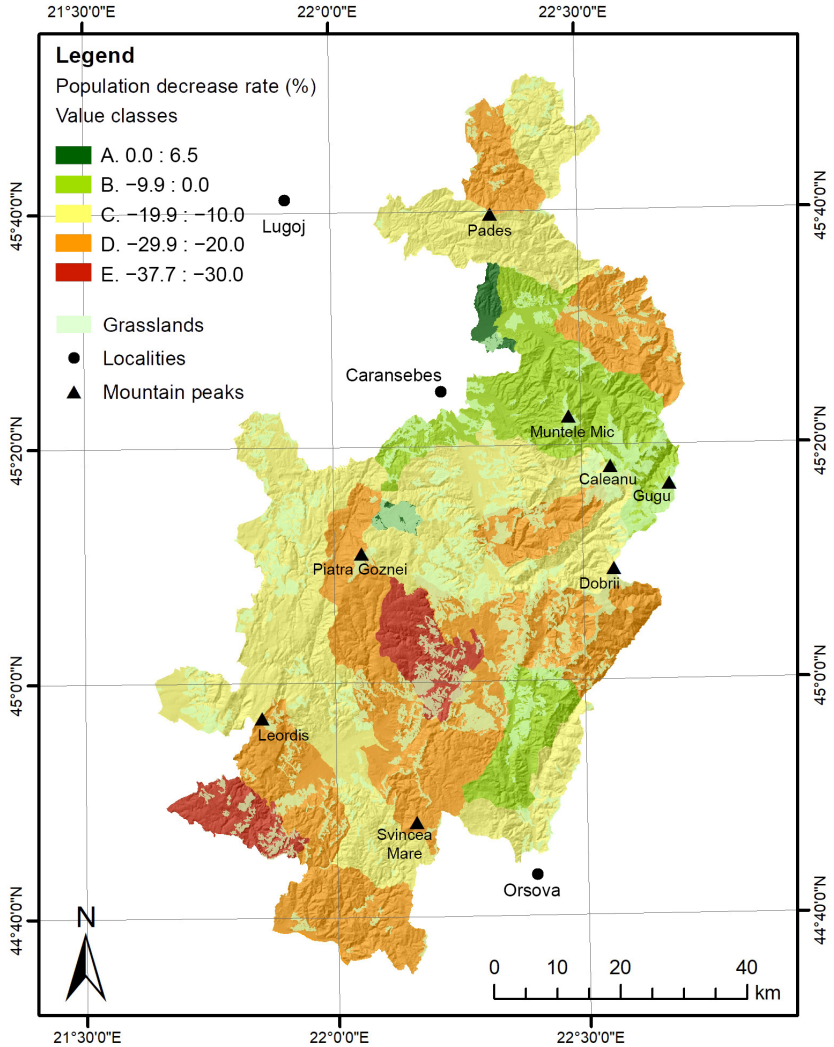


Figure 9. Framing of ATUs into classes depending on the rate of the reduction of the population (processed using data from [28,53,57,60]).

Repartition of ATUs in different classes (subareas) depending on the evolution of the number of inhabitants was performed as follows:

—Subarea A—with an increase in the number of inhabitants between 0.0 and 6.5% in two ATUs (Brebu Nou and Glimboca), with a surface area of 7596 ha;

—Subarea B—with the reduction in the number of inhabitants between 0.0 and 9.9% in five ATUs (Zăvoi, Mehadia, Buchin, Turnu Ruieni, Oţelu Roşu), with a surface area of 89,354 ha;

—Subarea C—with the reduction in the number of inhabitants between 10.0 and 19.9% in 15 ATUs (Ciclova Română, Topleţ, Reşiţa, Bozovici, Anina, Pietroasa, Rusca Montană, Bucoşniţa, Teregova, Nădrag, Bănia, Slatina-Timiş, Băile Herculane, Bolvaşniţa, Caraşova), with a surface area of 227,098 ha;

—Subarea D—with the reduction in the number of inhabitants between 20.0 and 29.9% in 15 ATUs (Băuţar, Lăpuşnicu Mare, Eftimie Murgu, Armeniş, Iablaniţa, Domaşnea, Marga, Berzasca, Dal-boşeţ, Luncaviţa, Văliug, Cornereva, Prigor, Cornea, Tomeşti), with a surface area of 204,835 ha;

—Subarea E—with a reduction in the number of inhabitants between 30.0 and 37.3% in four ATUs (Lăpuşnicel, Cărbunari, Mehadica, Şopotu Nou), with a surface area of 33,117 ha.

a. Analysis grasslands—population in subarea A

In subarea A, 2900 ha of grasslands were identified in the year 2018 (3.53% of the total surface of the grasslands in the study area), showing a relative decrease of 3.14% in comparison with the year 1990 (94 ha) (Table 6). During the analysed time interval, 650 ha (22.41%) of grasslands were affected by changes. As net changes (Figure 10), the significant increases in the grassland surface were determined by land surfaces coming from agricultural land with natural vegetation (17% of the total of the changes) and complex crops (8% of the total of the changes), and significant losses were produced by the transformation of the grasslands into orchards (37% of the total of the changes) and forests (7% of the total of the changes).

Table 6. Analysis of the changes in grassland surfaces in relation to the variation in the number of inhabitants.

Subarea/Class of Population Reduction		Grassland Surface (ha/% of the Total Surface)		Analysis of the Changes in the Grassland Surface during 1990–2018				
				Changeless Grassland Surface (ha/% of the Grasslands of the Subarea)	Changes in Grassland Surfaces (ha)			Net Changes (ha/Variation Rate 1990–2018)
		1990	2018		Surface Gain (ha/% of the Plus per Subarea)	Surface Losses (ha/% of the Minus per Subzone)	Total (ha% of the Grasslands of the Subarea)	
A	0.0:6.5	2994	2900	2622	278	372	650	−94
		3.86	3.53	90.41	9.59	12.83	22.41	−3.14
B	−9.9:0.0	16,151	16,756	14,636	2120	1515	3635	605
		20.83	20.41	87.35	12.65	9.04	21.69	3.75
C	−19.9:−10.0	25,285	27,739	20,080	7659	5205	12,864	2454
		32.77	33.78	72.39	27.61	18.76	46.37	9.70
D	−29.9:−20.0	26,202	28,830	20,754	8076	5448	13524	2628
		33.96	35.11	71.99	28.01	18.90	46.91	10.03
E	−37.3:−30.0	6528	5879	4868	1011	1660	2671	−649
		8.46	7.16	82.80	17.20	28.24	45.43	−9.94
Total		77,160	82,104	62,960	19,144	14,200	33,343	4944
		100	100					
% of total/2018		93.98	100	76.68	23.32	17.30		6.41

b. Analysis grasslands—population in subarea B

In this subarea, grasslands occupied 16,756 ha in the year 2018 (20.41% of the total study area) with a relative increase of 3.75% compared with the year 1990 (605 ha) (Table 6). In the analysed time interval, changes were observed on 3635 ha of grasslands (21.69%). The net change of the grassland surface by 605 ha was determined mainly by (Figure 10) surface increases in the agricultural lands with natural vegetation (14% of the total changes),

arable land (12% of the total changes) and complex crops (8% of the total changes) and by surface reduction due to the transformation in forests (15% of the total changes).

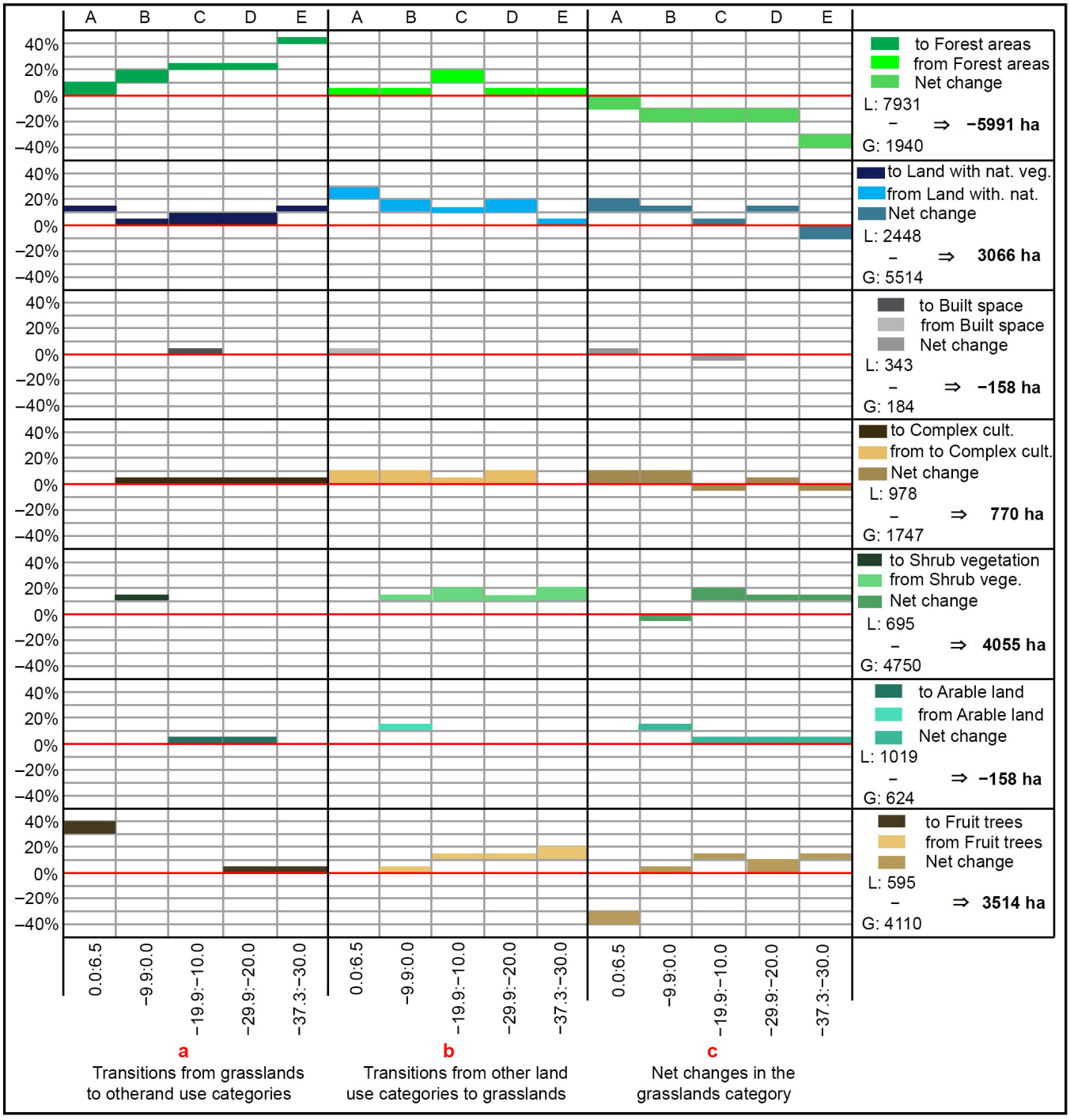


Figure 10. Analysis of the contributions to the changes that occurred in the grassland category by variation rate of the number of inhabitants.

c. Analysis grasslands—population in subarea C

In the year 2018, 27,739 ha of grasslands were identified in subarea C, which is 33.78% of the total surface of the study area. Compared with the year 1990, this was registered as a relative increase of 9.70%, representing 2454 ha, and the surface affected by changes was 12,864 ha (46.37%) (Table 6). The net value was formed mainly due to the increase in the surface of lands with shrubby vegetation (18% of the total changes) and orchards (15% of

the total changes). The surface reductions occurred due to their transition into forest areas (15% of the total changes).

d. Analysis grasslands—population in subarea D

In subarea D, grasslands covered 28,830 ha in 2018 (35.11% of the total grassland surface in the study area), with a relative increase of 10.03% compared with the year 1990 (2628 ha) (Table 6). In the analysed interval, changes occurred on 13,524 ha of grasslands (46.91%). The net changes (Figure 10) mainly occurred as surface increases in the agricultural lands with natural vegetation (15% of the mobilised land surfaces), lands with shrubby vegetation (11% of the total changes) and orchards (11% of the mobilised land surfaces), and as surface reduction from the transformation of the grasslands into forests (17% of the mobilised land surfaces).

e. Analysis grasslands—population in subarea E

In this area characterised by the highest rates of population reduction, in the year 2018 grasslands occupied 5879 ha (7.16% of the total surface of grasslands in the study area), with a relative decrease of 9.94% (649 ha) compared with the year 1990. In this subarea, changes were produced on 2671 ha of grasslands (45.43%). The net changes (Figure 10) were produced mainly by surface increases of the land covered with shrubby vegetation (15% of the mobilised land surfaces) and orchards (13% of the total changes). The reduction of the land surfaces occurred due to the transformation of the grasslands into forests (40% of the total changes) and lands with natural vegetation (10% compared to the sum of mobilised surfaces).

3.3.2. Quantitative Evaluation of the Grasslands via the Grassland Anthropic Impact Index (GAII)

For the quantitative expression of the relationship between grasslands and population, the application of the Grassland Anthropic Impact Index (GAII) was proposed. The index offers information referring to human resources and grassland resources (Figure 11).

In the calculation of GAII, initially only the area of grasslands assigned to each inhabitant at the level of ATU was reported, resulting in GAIIt. Later, only the segment of the working-population group (named active population) aged between 15 and 64 years was selected from the total population, on the principle that this segment of the population is a potential user of the grasslands; in this case, the grassland surface of each ATU was related to the active population, thus resulting in GAIIa.

It can be noted from Figure 11 that the values of GAII may vary between 0.015 and 13.00 ha/inhabitants. If we refer to GAIIt, higher values are observed in areas with low population densities and low values in populated areas with depressions and accessible areas. GAII values change over time, mainly due to the reduction in the population.

The results of GAIIa have greater values that grow with the reduction in the population. It was noted that in some areas, GAIIa value can reach 13 ha/inhabitant (Figure 11).

The average value of GAIIt in 1990 was 0.884 ha/inhabitant and in 2018 was 1.070 ha/inhabitant.

The average value of GAIIa at the beginning of the analysed interval was 1.325 ha/inhabitant, and at the end of the interval was 1.640 ha/inhabitant.

The relative percentual increase of the values of GAII is due in most of the cases to the reduction in the number of inhabitants. GAII values increase with the population decrease and the grassland area increase.

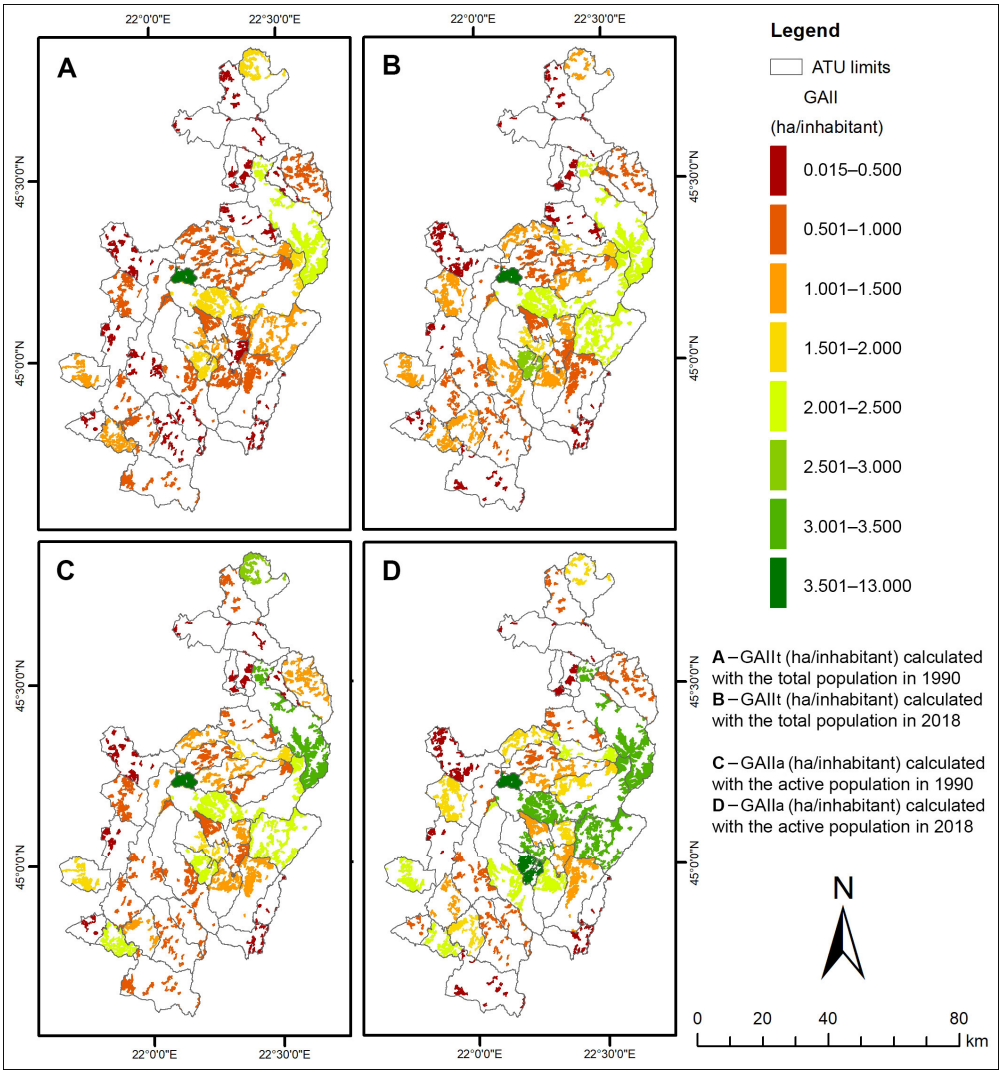


Figure 11. Distribution of grassland surfaces according to GAII values.

4. Discussion

It is important to consider the regional particularities characterised by economic, social and political conditions, variable in time and space [19,70,71] in any region of the globe, including in the mountain area of the Banat region, where there are several characteristic and in some cases contrasting aspects to observe, specifically the subsistence nature of agriculture, the climatic and pedological restrictions and, last but not least, the depopulation of the area.

The mountainous Banat region in Romania is well represented in terms of grassland surfaces (approx. 14% of the land fund), which an aspect also favoured by the physical–geographical conditions, and from a cultural and traditional aspect this area has always been associated with animal husbandry and pastoral culture. Unfortunately, following the observations in the field, it was found that their return is reduced as a result of their lack of management or even their abandonment—a situation also found in other mountainous areas of Romania [72–74].

4.1. Implications of the Changes in the Structure of the Land Fund at the Regional Level

Scientific research performed in different areas of the world has demonstrated the "mobility" of land use categories as the result of a complex of natural and/or anthropic

factors [45,47,48,75]. These changes can act on the ecological stability of the region [50] and by their nature can produce negative or positive effects on the ecological environment [76].

The spatial–temporal "mobility" phenomenon in land use was also identified in the study area, on the basis of the maps of coverage/use of the land obtained by the processing of the database CLC for a period of 28 years (1990–2018), analysed using overlay analysis and the LCM tool. Thus was established the rural character of the analysed area: the exploitation of the arable lands and orchards is dominant in the depression area, advancing towards the mountain area, where the exploitation of the grasslands and forests is dominant in the profile of the activities.

Essential changes occurred mainly during the 2006–2012 period on the back of the EU CAP policies. In general, a trend of expansion of the forest area was noted, mainly in the high mountain areas as a direct effect of the abandonment of the agricultural activities in these areas, while in the lowland areas appeared the trend of expansion of the arable land and grasslands.

At the level of the study area, the changes in land use that occurred can have environmental effects by their change to the structure and typology of the vegetation and the loss or diminishing of the habitat of some plant and animal species. Also, economic imbalances can occur, keeping in mind the fact that each land plot has its well-defined role in the budget of family farms. From a sociocultural perspective, the diminishing or transformation of the grasslands into lands with other uses has the effect of losing some pastoral traditions specific to different subareas.

4.2. Models in the Mobilisation of the Grassland Surfaces

In the studied mountain area, grasslands have and continue to have an important role, on the one hand due to their large share in the structure of the land fund (approximately 14%), and on the other hand due to their multifunctional character, which means varied possibilities of use. In this context, grasslands represent an important segment of regional economics [77] which has been mentioned since ancient times, during which the inhabitants of the area capitalised on the resources they offered, laying the foundations for a remarkable and original pastoral life [78] and a significant amount of trade with neighbouring areas and even other countries.

The grassland surface of the study area suffered changes in time and space during the research interval (1990–2018), in some areas as surface increases from the addition of lands with other uses and/or as surface reduction in other areas, due to the conversion of the grasslands into other categories of land use.

Great grassland surfaces located at the point of contact with the forest area were affected by the afforestation phenomenon due to their abandonment; this phenomenon is present in other mountain areas, too [79–83], related mainly to the anthropic factor. Secondary seminatural grasslands have appeared after deforestation works in the past [84,85].

Due to the afforestation of the grassland, there is a risk of losing some of the biodiversity "hot spots", considering the fact that in Romania the grasslands host the highest biodiversity in Europe [86]. Secondary grasslands were developed over centuries or even millennia in parallel with the pastoral activities of early human societies. Thus, on these land surfaces evolved specific rich and complex habitats, hosting a great diversity of flora and fauna that nowadays are considered to accomplish numerous environmental services besides specific economic roles. Keeping these secondary grasslands open instead of subjecting them to afforestation is very important in the conservation of these valuable biodiversity-rich habitats that most often host rare or endemic species of flora and fauna, comparable in biodiversity with the tropical forest. The very rich biodiversity pools represented by the secondary grasslands can be lost totally in the case of afforestation of these areas. This genetic resource has great importance, and cannot be neglected because it has a great potential for different uses, e.g., new crops, resistance genes, valuable molecules for pharmaceutical purposes, new technical crops, new forager crops, new amenity and

ornamental species, pollinator refuges, habitats for herbivores, sources of feed for domestic and wild animals, etc.

Thus, grasslands were transitioned to the category of agricultural land with natural vegetation in the areas with lower altitudes, and to the category of land with shrub vegetation in the areas with higher altitudes, as a result of their underexploitation or abandonment. In other areas, the conversion to arable land was noticed as an effect of the diversification of the agricultural production.

In the depression areas and in the areas at the base of the mountains, grasslands have gained surface area from the agricultural land with natural vegetation, land with shrub and forest vegetation and orchards as a result of the "clearing" of those lands for the use of grazing and or hay cutting. On the back of the financial incentives granted for the grasslands, the "recovery" and use of these lands for agricultural purposes was boosted.

As demonstrated in the study, grassland surfaces are "mobile" in time and space. Although, as a whole, there was a net increase the areas of 4944 ha, in reality the grassland surface affected by the changes was 33,343 ha, which shows that the pressure on the grasslands was manifested across large areas.

4.3. Population Evolutive Trends in Mountain Areas

Any type of regional development strategy must have a demographic component as its central element, thus making it possible to intervene in the deficient areas and support those with potential. The inductive analysis of the demographic data outlines the image of the past and present phenomena, and deductively the processes and defining factors in the stability and subsequent evolution of the demographic components can be noted.

Depopulation of the mountain areas has affected different parts of the globe at different rates and stages. Thus, in Western Europe, in the area of the Alps, the rural exodus began after the Second World War [87], and in Eastern Europe a little later. In Romania, once the changes were produced after the end of the totalitarian period (year 1989), the populations of the mountain areas migrated in a first phase to the big cities from the plain areas, and in the next phase they went to work abroad.

During the period 1990–2018, the number of inhabitants in the study area fluctuated, both from one temporal threshold to another, and from one subarea to another (Figures 7 and 8). The differentiations in the territorial profile, regarding the population distribution and the values of the demographic indicators, are determined to a large extent by the complex physical–geographical conditions, as it is a mountainous area with an extension of approximately 2000 m altitude.

The reduction in the human population in the Mountain Banat area occurred through two mechanisms: through the reduced birth rate (which is strongly signalled by the ageing of the population) but also through the rural exodus, manifested both through internal and external migration. The rural exodus occurred largely as a result of the cessation of industrial and mining activities after 1989 (the year of the transition from communism to democracy in Romania).

In addition to the continuous reduction in the number of inhabitants, in most of the analysed cases, the study area is faced with accentuated population ageing phenomena as a result of the decrease in mortality (increase in life expectancy) and the decrease in the birth rate and migratory phenomena [67,88].

From an ecological perspective, lower population densities in a territory could reduce anthropic pressure on the environment, but can have negative implications on the processes of resource exploitation (e.g., grasslands) or the socioeconomic and cultural development of mountain areas.

4.4. Consequences of Population Reduction on the Grassland Surfaces

Due to the nature of the transformations that have occurred in the class of grasslands, the contribution of the anthropic factor is obvious: in the lowland, better populated areas, grasslands gain land from other categories of land use, but in the areas at higher altitudes,

grassland surfaces are lost through afforestation, which is a process in different stages of development. The results are in conformity with other studies that show the conversion of the grasslands into lands with other uses through human intervention [89].

The analysis of the net transformations identified in the category of the grasslands (4944 ha), in correlation with the variation in the number of inhabitants, highlighted the following aspects: the transition of the grasslands into the category of forests (7931 ha), one of the most significant changes, occurred increasingly due to the accentuation of population reduction; the transformation of the agricultural lands with natural vegetation (lands interspersed with the grasslands and other agricultural lands) into grasslands over an area of 5514 ha occurred mainly in the areas affected at a lower rate by the population reduction; the share of these changes from the total changes is much more reduced as the population deficit increases; the transformation of lands with shrubby vegetation (lands in contact with the grasslands and forests) into grasslands (4750 ha) occurred mainly in the areas with higher altitudes, which are isolated and depopulated, and where the grassland ecosystems tend to recover to their initial state of forest. In the opposite way, in the areas with increases in the number of inhabitants, the transformation of the grasslands into orchards was noticed.

On the map of the transitions, it is possible to identify the areas that passed into the category of grasslands from forests and arable land—areas that require ecological restoration.

According to the data from the literature, there are different methods and indicators of quantitative and qualitative assessment of the grasslands, specifically of their biodiversity and conservation state [90,91], grassland degradation [92,93], keeping in mind the classification of the grasslands [94], and intensity of land use [95], achieved by the application of some indexes and methods of remote sensing, GIS and photogrammetry [96–99], etc. In this research, the Grassland Anthropic Impact Index (GAII) was applied, which is an index that shows the potential use of the grasslands by the inhabitants of the area. This analysis was based on the following consideration: the grasslands as a natural resource with a multifunctional role are used directly and/or indirectly by the inhabitants of the analysed area.

The values of GAII calculated at ATU level were greater at the end of the analysed time interval (year 2018), both in relation to the total population (GAIIt) and to the working-age population (GAIIa), mainly due to the reduction in the number of inhabitants. The fact that the grassland surface considered for each inhabitant increased can have different meanings: it is an advantage, if the grasslands are properly used for socioeconomic purposes, but it can draw attention to the threat of deterioration and abandonment if they are not used properly.

An important aspect is the fact that specific situations or regional differences can be analysed by spatialising GAII values. Where necessary, specific actions can be applied to protect and preserve the habitats and to manage the risks or stimulate the areas where the resources are underexploited.

In another context, due to the numerical reduction in the population of the mountain areas, pressure is placed on the remaining inhabitants, who have a larger area of grassland "under management".

In terms of the sustainable management of the study area, the decision makers can rely on such studies that, on the one hand, evaluate the dynamics in time and space of the grassland surfaces and, moreover, identify the areas that present the risk of being lost (through afforestation and/or switching to another land use, etc.).

In the present situation, decision makers from local councils, managers of protected areas, volunteers and other associations and entities from mountain areas at risk of depopulation and abandonment of grasslands can and should get involved in grassland management, depending on the situation. For example, in grassland originating from abandoned arable land, they must create a set of measures for ecological restoration. If the grassland is covered with a lot of shrubs and invasive plants, these need to be cleared to avoid the loss of biodiversity and ensure conservation. On the other hand, the competent

authorities should facilitate and provide logistical support to farmers to access financial support measures offered by EU CAP policies and/or national programmes to maintain all land use categories, all of which play an important role in the maintenance of grassland biodiversity and conservation.

4.5. Limitations and Perspectives

The application of this type of analysis depends on the available geospatial or statistical data, considering the fact that their accuracy and precision depend on the spatial resolution of the data used.

Automation is necessary for the application of the workflow, at least in stages, considering the long execution time and the large volume of data that must be processed.

GAII can take on a hypothetical form in that not all individuals of working age are exploiting the grasslands, and some of the inhabitants included in this segment may be inactive, but regardless of their socioeconomic status, all are "implicit heirs" of the resources of grasslands in the given area, thus they can be seen as a part of the potential use of these land surfaces.

Only the influence of the human factor on land use was taken into account in this study, through the variation in the number of inhabitants; however, further studies could be completed by including other factors that contribute to changes (e.g., natural factors) as a future direction of research.

Another challenge will be to expand the workflow from local levels to regional levels at optimal spatial and temporal scales, so that research results can be integrated into plans and strategies for rural development and human wellbeing.

5. Conclusions

At the level of the study area, the spatial and temporal distribution of land use classes is dominated by forest areas, followed by grassland areas and, to a lesser extent, mosaic areas and land with other uses (arable land, shrubland, orchards and vineyards, etc.).

Between 1990 and 2018, grassland surface has shown a net increase due to the addition of areas of agricultural land with natural vegetation, land with shrub vegetation, fruit plantations, etc. Nonetheless, it has suffered decreases from the loss of areas through afforestation (conversion to forest areas), abandonment (conversion to agricultural land with natural and shrub vegetation) and change of the use category (conversion to arable land). The increases in the area occurred mainly after 2006, on the back of sociopolitical and economic changes that occurred in Romania.

Over the analysed period (1990–2018), the number of inhabitants has decreased, but there were significant territorial disparities. The reduction in the number of inhabitants has also negatively influenced the values of other significant demographic indicators such as population density, dependency ratio and demographic ageing index. These changes have consequences in terms of the exploitation of natural resources, lack of interest in developing transport and building infrastructure at the local level, the dismantling of educational centres in villages with small populations (which means students commuting daily to the centres of communes or towns and even dropping out of school), lack of jobs, and reduced interest in social and building services. All of these lead to the increase of poverty and reduction of living standards, which encourage migration phenomena.

Although Romania, as an EU Member State, benefits from funds designated for the conservation and exploitation of grassland areas or the socioeconomic development of rural localities, demographic decline may jeopardise or even diminish the interest or the intention for accessing these funds.

The present analysis of the transformations occurring in the grassland class shows the contribution of the human factor, through its actions, on the direction of these transformations: in better populated areas with agricultural activities, grassland gains land from other categories of land use, but in high mountain areas with low population densities, grassland areas are lost through abandonment.

The Grassland Anthropic Impact Index (GAII) reported on both the total population and the segment of the working population group, which also showed regional differences and had higher values towards the end of the analysed interval. This may have a positive impact if grasslands are properly used for economic purposes, but also negative implications due to the threat of degradation and abandonment of grassland surfaces.

The results of the present study can be used both as a theoretical basis for regional scientific research, but also as a practical tool for assessment, diagnosis and forecasting in this study area or other regions and, depending on the purpose, in various fields: agriculture, environment, cadastre, spatial planning, etc.

The results of the study, in part or in full, can be used in local and regional development strategies, in projects for the protection of environmental factors and natural resources or in land-use plans, which are particularly important for local communities.

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