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LAND COVER CHANGES WITHIN GIURGIU COUNTY, ROMANIA

MODIFICĂRI ALE ACOPERIRII TERENULUI ÎN JUDEȚUL GIURGIU, ROMÂNIA

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Abstract: Post-communist transformations have led to significant land cover changes in Giurgiu County, Romania, resulting from a shift in land management practices. The area transitioned from a collectivized agricultural system to liberalized farming methods in the early 1990s, followed by the emergence of centralized management under large-scale agricultural enterprises. Currently, Giurgiu County is characterized by a predominantly agricultural landscape, with 77.8% of its area used for agricultural purposes as of 2022. Arable land is particularly notable, comprising 73.4% of the county's total area in 2022. These lands are primarily cultivated with cereal crops and oilseed plants. The natural landscape quality is markedly influenced in certain administrative-territorial units by the dominance of arable fields.

Key-words: *Corine Land Cover, Human Pressure Index, Giurgiu county*
Cuvinte cheie: *Corine Land Cover, Indicele Presiunii Umane, județul Giurgiu*

1. INTRODUCTION

Giurgiu County overlaps an area of 3,548 sqkm according to data available at the National Agency for Cadastre and Land Registration (NALCR, 2024) and had a resident population of 258,790 as of July 1, 2023 (National Institute of Statistics, 2023). Situated in southern Romania (Fig. 1), within the South-Muntenia Development Region, it borders Teleorman County to the west, Dâmbovița to the north, Ilfov to the northeast, and Călărași to the east. To the south, Giurgiu County the limit is represented by the interstate Romania-Bulgaria border placed on the Danube River. The Danube flows the county for approximately 72 km, entering at Găujani and exiting at Prundu.

The county's geographic center is defined by the intersection of the parallel 44°12'2.55''N latitude and the meridian 25°56'10.75''E longitude. Its administrative seat, Giurgiu municipality, is situated only 60 km southwest of Bucharest, the capital of Romania. Giurgiu County is organized into 54 administrative-territorial

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units (NACLR, 2024), of which 51 are rural settlements and three are urban: the county seat Giurgiu and the towns Mihăilești and Bolintin-Vale.

From a physical-geographical perspective, Giurgiu County includes the Danube Floodplain at its southern boundary, Burnas Plain between the Câlniștea River and the Danube Floodplain, characterized by substantial loess deposits (Florea & Munteanu, 2012), Găvanu Plain north of the Câlniștea River, small portions of Titu and Ilfov Plains in the northeast and minor areas of the Argeș-Sabar Floodplain and Câlnău Plain in the southeast (Posea et al., 2005). The relatively flat terrain and favorable soils promote extensive agricultural activity.

The parent material for soils is predominantly loess across most of Giurgiu county, except for the northwest, where fluvio-lacustrine clay materials prevail (Florea et al., 2015). The most common soil types are Calcic Chernozem, Vermi-Calcic Chernozem, Luvic Phaeozem and Luvi-Vertic Phaeozem in the southern half of the county and Chromic Luvisol, Pellic Vertisol in the northern half (Akça et al., 2005).

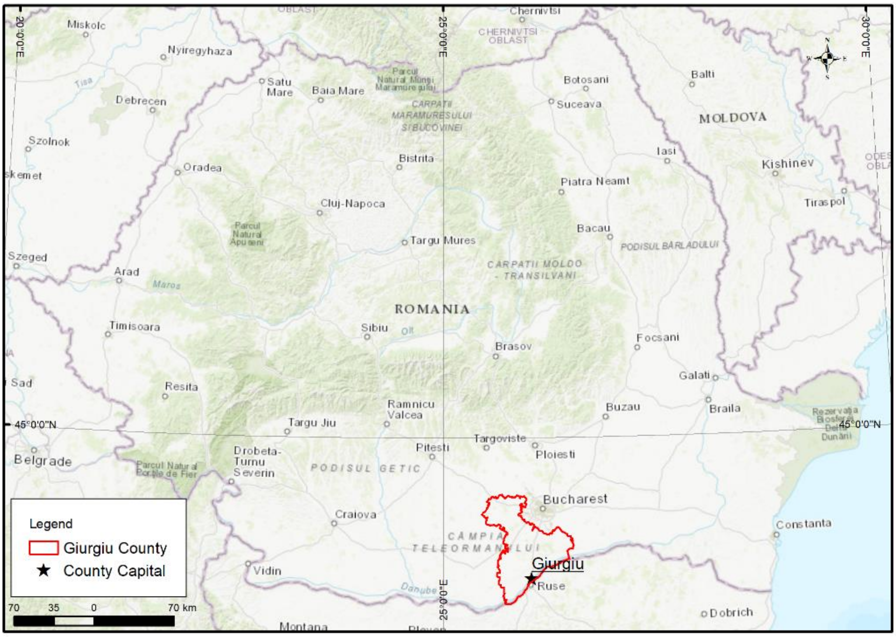

Fig. 1 Giurgiu County position within Romania
(Source: NACLR and ESRI Topographic basemap)

The natural vegetation corresponds to the floodplain, steppe and forest-steppe zones, but is largely replaced by agricultural crops, except for a few small patches of forest composed mainly of *Quercus cerris, Quercus frainetto*, *Quercus pubescens* and *Quercus pedunculiflora* (Posea et al., 2005). Among the shrub species present, there can be mentioned Cr*ataegus monogyna*, *Ligustrum vulgare*, *Rosa canina*, *Prunus spinosa*, *Cornus sanguinea* and *Cornus mas*. The main forested areas in Giurgiu County include Comana Forest - which is also a protected area - Călugăreni Forest, Singureni-Deal Forest and Căscioarele Forest.

The predominant grasses include *Festuca* sp., *Chrysopogon gryllus*, *Carex* sp., and *Poa pratensis*, while the steppe meadows are mainly populated by xerophilous species such as *Festuca*, *Agropyron repens*, *Poa pratensis*, *Stipa pennata*, *Stipa capillata*, *Echinochloa crus-galli* and *Artemisia absinthium* (Grecu, 2015).

Climatic conditions indicate increasingly higher annual average temperatures, with the 2024 average exceeding 14°C, while annual precipitation remains relatively low, totaling 500-600 mm (National Meteorological Administration).

2. DATA AND METHODS

Most of the data used in this study are from CORINE Land Cover (CLC) time series. CLC data for the years 1990, 2000, 2012 and 2018 from the European Environment Agency's Copernicus Land Monitoring Service were used. CLC data were downloaded from https://land.copernicus.eu/.

The CLC (CORINE Land Cover) layers have undergone substantial improvements over time. For instance, in 1990, CLC data were derived from Landsat-5 MSS/TM imagery, which provided a geometric accuracy of 100 meters and a thematic accuracy of 85%. In 2000, data acquisition switched to Landsat-7 ETM, while in 2006, SPOT-4/5 and IRS P6 LISS III sensors were utilized. By 2012, IRS P6 LISS III and RapidEye imagery were employed. For the 2018 dataset, Sentinel-2 data were used, with Landsat-8 imagery serving for gap filling. As a result, the geometric accuracy of satellite data improved to less than 10 meters and the thematic accuracy of the CLC product exceeded 85% (CORINE Land Cover — Copernicus Land Monitoring Service).

National-level studies on land use and land cover changes using CLC data have been conducted (Popovici et al., 2013), revealing significant modifications in some cases, especially about the expansion of built-up areas.

Additional land use data was sourced for the year 2022 from National Institute of Statistics (insse.ro) and Giurgiu County Statistics Directorate (GCSD, giurgiu.insse.ro).

Considering the extent of agricultural use of terrain in Giurgiu County, which is the main use, the human pressure index (HPI) at the administrative unit level was also calculated, to show the impact on the environment caused by the land use as arable land. To determine the HPI, there were used statistical data from the National Institute of Statistics for the years 2000, 2012, and 2022 and for comparison purpose, CORINE Land Cover (CLC) time series data.

Human pressure index exerted through arable land was computed using the formula below as presented in Pătru-Stupariu, 2011.

$$HPI = Surf./Pop. \quad (1)$$ where:

HPI = human pressure index exerted through arable land:

Surf. = the surface of the area for arable land;

Pop. = the numbers of the inhabitants living in an administrative-territorial unit.

Following the classification presented in Ursu, 2014, the results were grouped into:

1. Well balanced rural landscape (<0.40 ha/inh.);
2. Moderate and slightly affected landscape (0.41-1.00 ha/inh.);
3. High unbalanced rural landscape (1.01-2.00 ha/inh.);
4. Very high unbalanced rural landscape (>2.00 ha/inh.).

The software used to generate the HPI maps was ArcGIS Desktop 10.6.1, a comprehensive geographic information system (GIS) software suite, developed by Esri. Also, ArcGIS Desktop 10.6.1 helped to conduct the spatial analysis and cartographic representation of land cover changes within Giurgiu County and produce high-resolution maps that support the interpretation of environmental dynamics and human impact on the landscape (ESRI).

3. RESULTS AND DISCUSSIONS

In 1990, the area covered by discontinuous urban fabric within Giurgiu was 5.1% of the county's total area, equivalent to 18,112 hectares. This area increased slightly by 2000, reaching 5.1% of the total. By 2006, discontinuous urban fabric occupied 5.3% of the county, but decreased by nearly 0.3% in 2012. In 2018, discontinuous urban fabric covered 17,977 hectares or 5.06% of Giurgiu county's area.

The area used for industrial or commercial units shows a difference of 257.2 hectares between 1990 to 2018, from 2,768.7 to 2,511.5 hectares. This represents a reduction from 0.78% to 0.70% of the county's total area. The smallest area occupied by industrial or commercial units was 1,923 hectares in 2006 according to CLC, value not much smaller than 2008.53 ha registered in 2012. According to these data, although the area covered by this category is 250 ha smaller in 2018 compared to 1990, it increased by more than 500 ha compared to 2006.

Land occupied by roads and rail networks increased by only 1.64 hectares between 1990 and 2018, suggesting limited expansion or modernization of terrestrial transportation infrastructure. Proportionally, this category never exceeded 0.01% of the county's area.

In 1990, non-irrigated arable land (depicted in yellow on Fig. 2) encompassed 237,666 hectares, or 66.98% of Giurgiu County. By 2000, this increased to 238,283 hectares (67.1%), reflecting changes in agricultural practices following Romania's political transition. After 1990, much of the collective irrigation system was at least neglected, as land was redistributed to rightful owners who did not maintain irrigation infrastructure. The expansion of non-irrigated arable land continued after 2000, with Corine Land Cover data showing 240,724 hectares in 2006 (67.8%). By 2012, the area decreased to 230,302 hectares, potentially resulting from changes in land cover or the establishment of agricultural ownership associations that reinstated irrigation systems to enhance crop yields. According to Corine Land Cover data, in 2018, non-irrigated arable land covered 230,084 hectares.

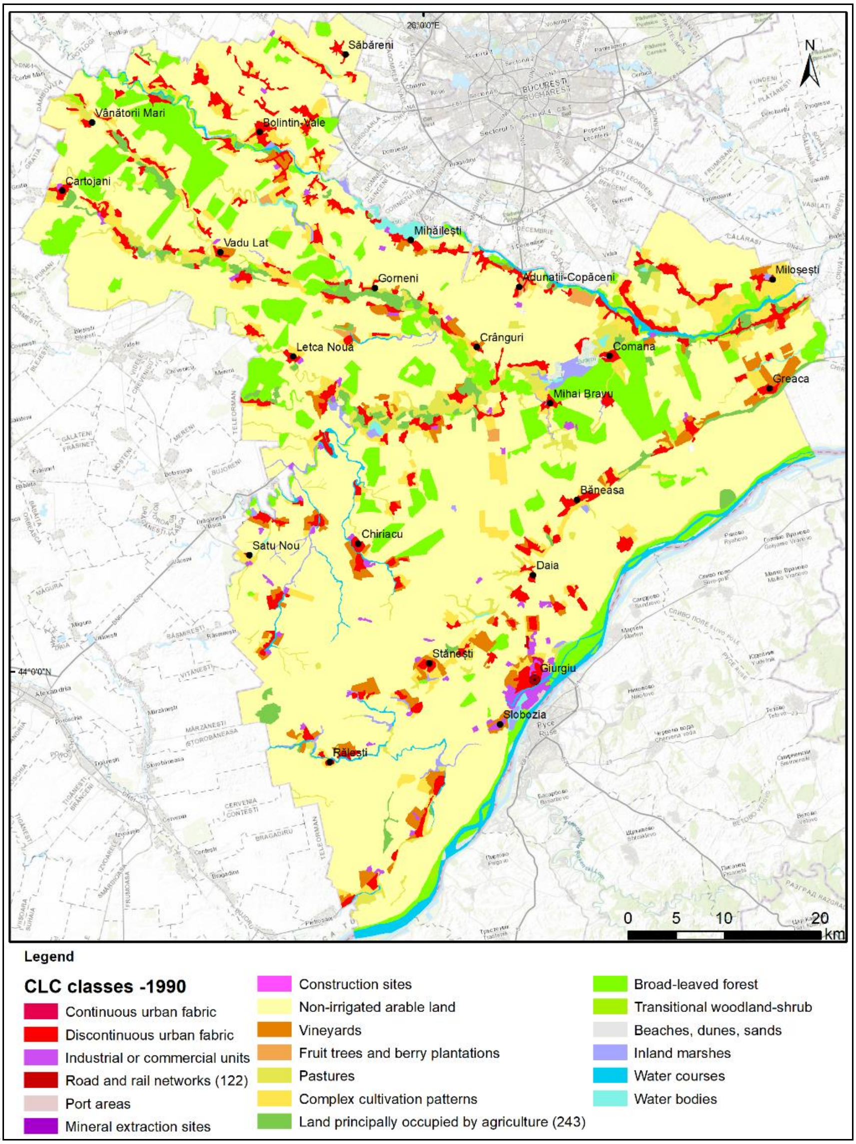

Fig. 2 Land cover and land use within Giurgiu County, 1990
(Source: https://land.copernicus.eu/en/products/corine-land-cover/clc-1990)

The area occupied by vineyards was 8,179.6 hectares in 1990, representing 2.3% of the county's surface. Over the next ten years, the vineyard area decreased by 113.4 hectares (to 2.27%). This downward trend continued, with the area dropping to 3,956.3 hectares (1.1%) in 2006, less than half the area dedicated to this crop in 1990. In 2012, CLC data indicate an increase in vineyard area to

6,041.8 hectares (1.7%) and in 2018 (Fig. 3), the area occupied by vineyards decreased slightly again, reaching 5,933.6 hectares (1.67%).

The port area remained unchanged from 1990 to 2018, at 74.93 hectares, occupying 0.02% of the county's surface. Currently, the port allows the docking of barges up to a maximum of 2000 t, and the main operators in the port of Giurgiu are SCAEP Giurgiu Port, S.C. DUNAPREF S.A., CNF GIURGIU NAV S.A. They operate bulk cargo, general cargo, cereals and petroleum products (https://apdf.ro/giurgiu.html).

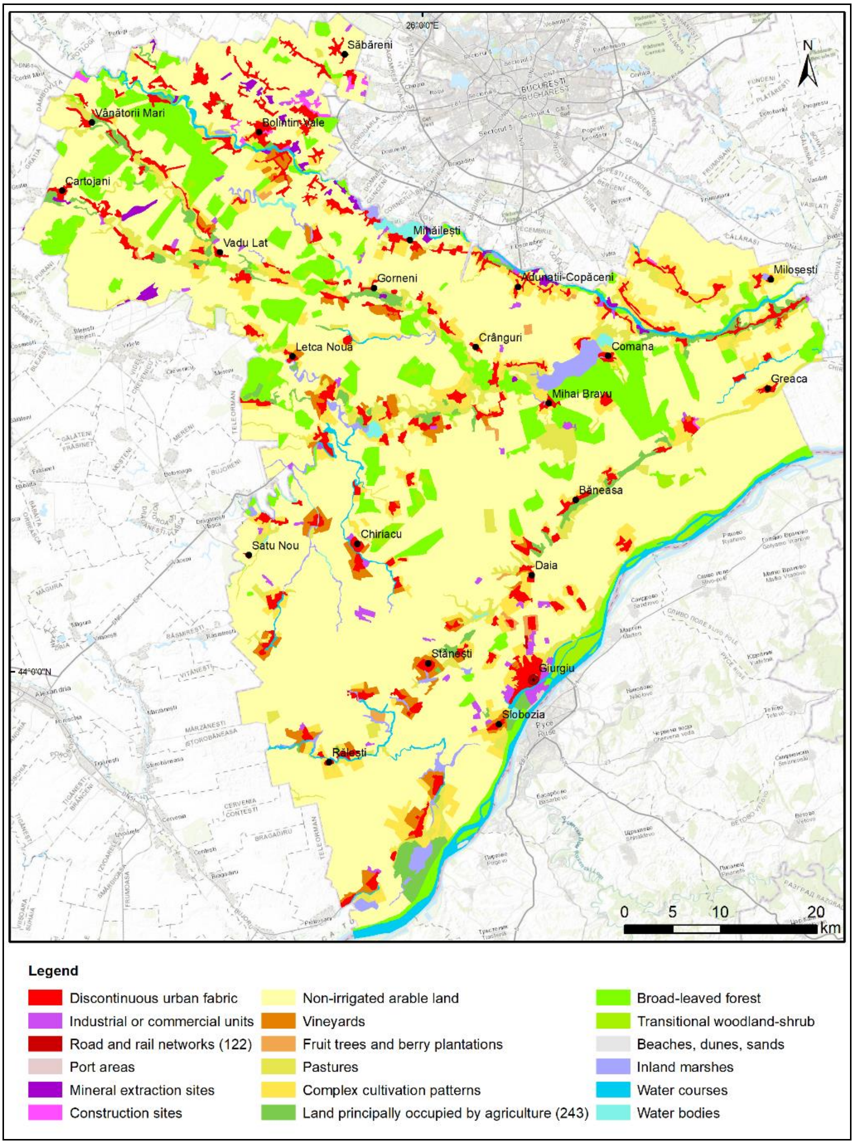

Fig. 3 Land cover and land use within Giurgiu County, 2018

(Source: https://land.copernicus.eu/en/products/corine-land-cover/clc2018)

The area occupied by fruit trees and berry plantations covered 0.25% of Giurgiu County in 1990, or 903.9 hectares. In 2000, the area remained unchanged compared to 1990, but from 2006 onward, it began to decline steadily, reaching 814.5 hectares (0.22%) in 2018.

Pastures accounted for 3.01% of the county's surface in 1990, totaling 10,713 hectares. By 2000, the area of pastures decreased by 185.4 hectares compared to 1990, but in 2006 it increased to 15,296.3 hectares, a rise of 4,583.3 hectares over 1990. In 2012, pasture area decreased to 14,270.3 hectares, making up 4.02% of Giurgiu county and in 2018, there was another decrease compared to the previous reference year (2012), with pastures occupying 13,810.3 hectares (3.89%).

Complex cultivation patterns covered 17,761.8 hectares in 1990, representing 5% of the county's surface. By 2018, this area had risen to 22,011 hectares, or 6.2% of Giurgiu county.

Land principally occupied by agriculture, with significant areas of natural vegetation, encompassed 7,464 hectares in 1990, or 2% of the county's surface. In 2000, this area decreased by 201.6 hectares compared to 1990. According to CLC data for 2006, the area shrank even more sharply to 4,888.9 hectares, a drop of 2,575.1 hectares from 1990. In 2012, the area increased to 7,070 hectares (1.99% of the county) and in 2018 it measured 7,047.2 hectares (1.98%).

Broad-leaved forest occupied 37,418 hectares in 1990, or 10.54% of Giurgiu county's surface. By 2018, this area had decreased to 35,242.7 hectares (9.93%), a loss of 2,175.7 hectares.

Natural grasslands are recorded in CLC data only for 1990, 2000, and 2006. In 1990, they covered 0.22% of the county's surface, or 792.6 hectares, a figure that remained almost unchanged in 2000. By 2006, however, this area had declined sharply to just 98.5 hectares (0.02%).

Transitional woodland-shrub covered 1,278 hectares in 1990 and increased to 3,366.5 hectares (0.94% of the county's surface) by 2018. The lowest value was registered in 2000, when transitional woodland-shrub occupied just 1,069.8 hectares.

Beaches, dunes and sands covered 423.2 hectares (0.1%) in 1990, dropping to 47.8 hectares (0.01%) by 2018.

Inland marshes occupied 2,546 hectares in 1990, nearly doubling to 4,704.7 hectares by 2018.

Water courses accounted for 6,964 hectares (1.96%) in 1990 and 7,390.7 hectares (2.08%) in 2018. Water bodies covered 1,692 hectares (0.47%) in 1990, declining to 1,539.6 hectares (0.43%) in 2018.

The above data presentation can be partly summarized in Table 1 where percentage of total county area occupied by CLC categories is shown for each of the years considered. Out of the 20 CLC classes identified within Giurgiu county (see Table 1), twelve categories experienced area losses between 1990 and 2018, while eight categories registered increases.

Graphs made using these datasets (Fig. 4) show little change if any for most of CLC categories in the considered years. Categories like Port areas, Road and rail networks and associated land, Discontinuous urban fabric, do not have major changes for the entire span of time covered by CLC data sets.

Table 1 Land cover evolution in Giurgiu county

CLC code	Description	Percentage of total Giurgiu County area (%) by year					Evolution 1990-2018
		1990	2000	2006	2012	2018	
211	Non-irrigated arable land	66.98551	67.15138	67.8365	65.17069	64.84122	loss
311	Broad-leaved forest	10.54616	10.59195	10.64935	10.15815	9.931902	loss
112	Discontinuous urban fabric	5.104874	5.123927	5.295412	5.056038	5.066263	loss
242	Complex cultivation patterns	5.006114	4.980372	4.575128	6.229212	6.203018	gain
231	Pastures	3.01943	2.966816	4.310517	4.038192	3.891942	gain
221	Vineyards	2.305398	2.273162	1.11489	1.709701	1.672174	loss
243	Land principally occupied by agriculture, with significant areas of natural vegetation	2.103708	2.04664	1.377698	2.00066	1.986003	loss
511	Water courses	1.962784	1.95739	2.04258	2.091411	2.082806	gain
121	Industrial or commercial units	0.78035	0.780282	0.541904	0.566099	0.707777	loss
411	Inland marshes	0.717583	0.717581	0.96965	1.356855	1.325852	gain
512	Water bodies	0.476886	0.477476	0.539029	0.391897	0.433882	loss
324	Transitional woodland-shrub	0.360201	0.301484	0.339965	0.760647	0.948728	gain
222	Fruit trees and berry plantations	0.254762	0.254562	0.23323	0.237589	0.229538	loss
321	Natural grasslands	0.223417	0.22339	0.02778	0	0	loss
331	Beaches, dunes, sands	0.119278	0.124508	0.051234	0.013526	0.013471	loss
123	Port areas	0.021119	0.016655	0.021115	0.021204	0.021116	unchanged
122	Road and rail networks and associated land	0.012429	0.012428	0.01289	0.012943	0.01289	gain
131	Mineral extraction sites	0	0	0.051775	0.439759	0.451157	gain
133	Construction sites	0	0	0	0.185181	0.180249	gain
312	Coniferous forest	0	0	0.009353	0	0	unchanged

(Source: CLC, https://land.copernicus.eu/en/products/corine-land-cover)

The category that covers the largest surface is Non-irrigated arable land, which grew till 2006, when it began to reduce, in 2018, the reduction representing almost 3% compared to 2006. The growth of almost 0.8% registered in 2006 compared to 2000 was made mostly using land previously used for the categories Complex cultivation patterns, Land principally occupied by agriculture, with significant areas of natural vegetation and Vineyards. This feature can easily be observed overlaying in ArcGis layers of the later three categories for year 2000 and the layer of the Non-irrigated arable land category for year 2006.

The surface of Vineyards category for 2006 was 1.15% smaller compared to the year 2000. This loss was made mainly in the favour of Complex cultivation patterns category. Data for the years 2012 and 2018 show an increase of the surface covered by Vineyards of 0.6% compared to data for year 2006. This growth was made on the expense of surfaces previously covered by Non-irrigated arable land and Complex cultivation patterns categories.

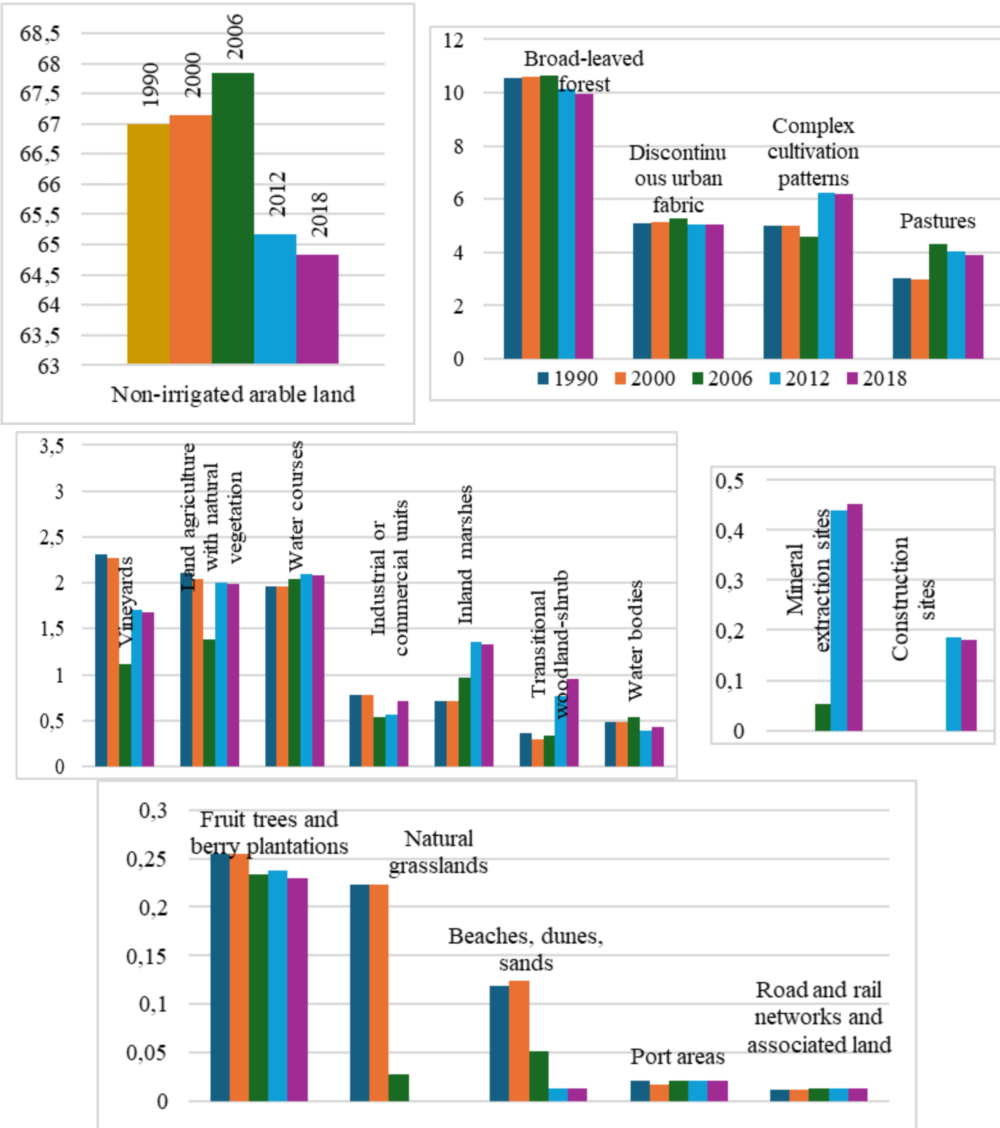

Fig. 4 Charts for land use evolution in Giurgiu county, Romania, according to CORINE Land Cover datasets for the years 1990, 2000, 2006, 2012, 2018. Vertical axes values represent percent of total county area.

Construction sites category is present in CLC datasets only for the years 2012 and 2018 covering 0.18% total county area.

Mineral extraction sites category is registered beginning with the year 2006 when it covers only 0.05%. In 2012 and 2018, the surface increased to 0.45%. This increase in surface is mainly due to sand and gravel quarries opened in northern part of the county.

In 2022, the agricultural area of Giurgiu county covered 276,059 hectares, of which 260,262 hectares were arable land meaning 73.4% of the total area of Giurgiu county (Fig. 5). 11,490 hectares were pastures, 414 hectares were hayfields, 3,085 hectares were vineyards and viticulture nurseries and 808 hectares were orchards and fruit tree nurseries (GCSD, 2022). 77.8% of Giurgiu county's territory was thus classified as agricultural land.

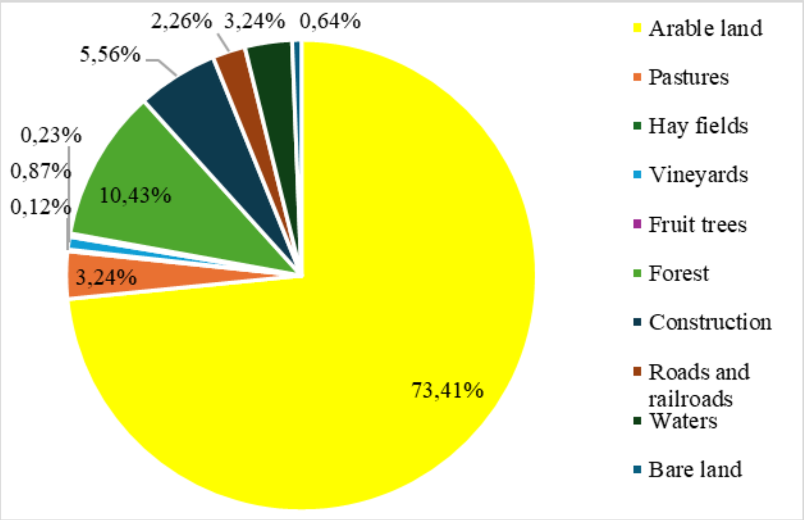

Fig. 5 Percentage of total area of Giurgiu occupied by land cover categories in 2022

(Data source: GCSD)

Forests and areas with forest vegetation occupied approximately 36,962 hectares in 2022, representing 10.4% of the county's surface area (GCSD, 2022).

Built-up areas in 2022 amounted to 19,707 hectares or 5.5% of the county's total surface, while roads and railways covered 8,020 hectares, representing 2.26% of the area.

Aquatic surfaces occupied 11,494 hectares in 2022, which is 3.24% of Giurgiu county's area.

Degraded and unproductive lands accounted for 2,269 hectares, or 0.64% of the county's area.

Given the considerable agricultural area in Giurgiu county, we conducted an analysis of the human pressure exerted by arable land for the years 2000, 2012 and 2022.

Considering the categories "well balanced rural landscape (2.00 ha/inh.)" (Pătru-Stupariu, 2011), it was found that in 2000 (Fig. 6), eleven administrative-territorial units could be classified as having a very high unbalanced rural landscape, with HPI values exerted by arable land greater than 2 ha/inh. Most of these units were in the western half of Giurgiu county, namely: Schitu, Izvoarele, Răsuceni, Toporu, Gogoșari, Putineiu, Stănești, Slobozia and Găujani. The highest HPI value, namely 5.37 ha/inh., was calculated for the locality of Gogoșari. Toporu had a HPI of 3.30 ha/inh., while Stănești recorded 3.18 ha/inh.

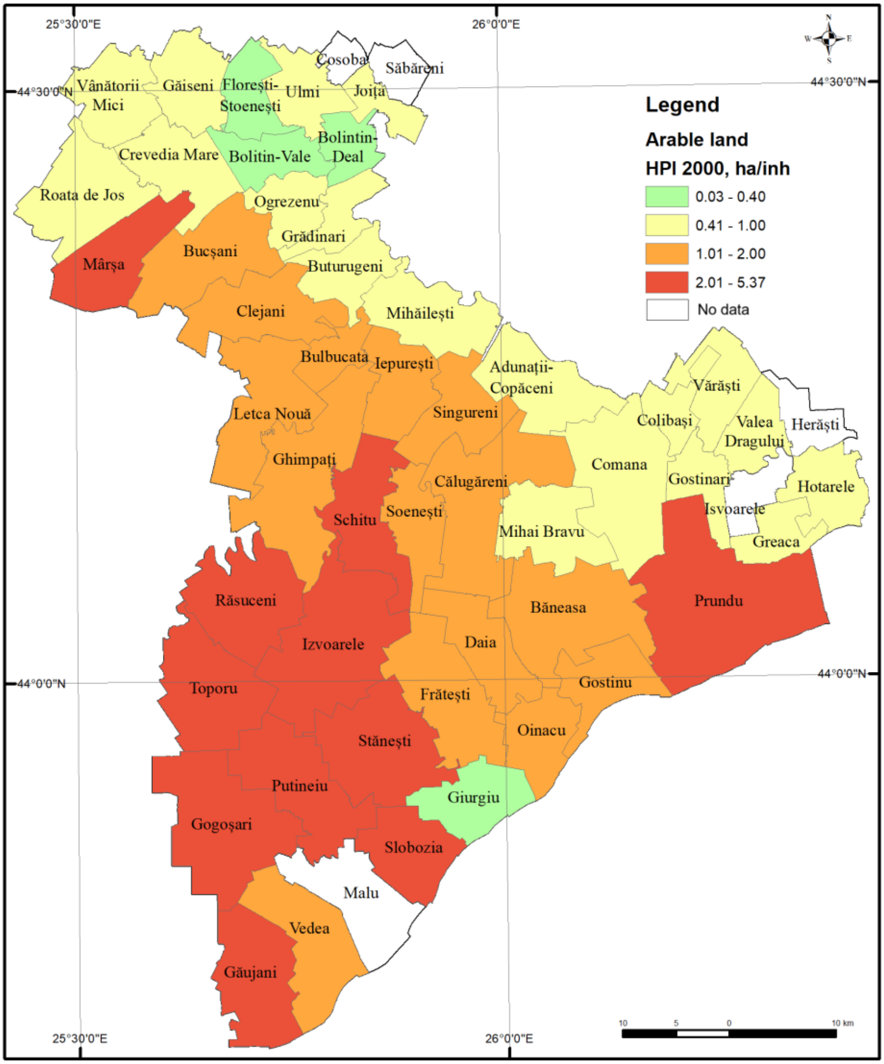

Fig. 6 Values of HPI exerted by arable land in 2000
(Data source: INS)

High unbalanced rural landscapes (1.01-2.00 ha/inh.) were recorded for 15 administrative units in Giurgiu county.

In 2012 (Fig. 7), the number of administrative units with a very high unbalanced rural landscape increased to thirteen. Once again, the highest value, namely 6.03 ha/inh., was registered within the boundaries of Gogoșari, while for Toporu the HPI exerted by arable land was 4.12 ha/inh. The localities of Putineiu, Izvoarele and Răsuceni had HPI values ranging from 3 to 4 ha/inh.

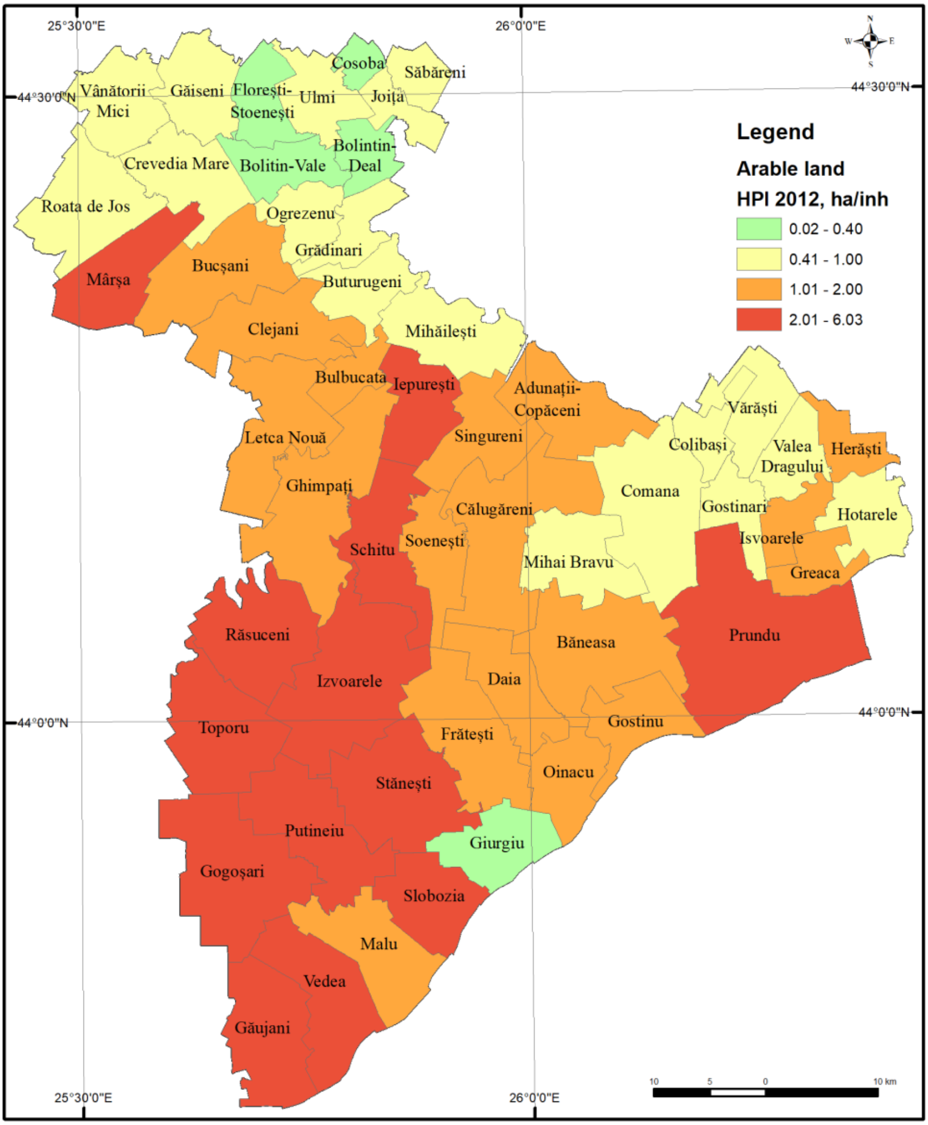

Fig.7 Values for HPI exerted by arable land in 2012
(Data source: INS)

Eighteen localities in Giurgiu county had a very high unbalanced rural landscape due to the extensive area of arable land. As in 2012, only five localities fell into the category of well-balanced rural landscape (<0.40 ha/inh.), namely: Cosoba, Florești-Stoenești, Bolintin-Deal, Bolintin-Vale and the municipality of Giurgiu. In 2022 (Fig. 8), fifteen administrative units in Giurgiu county had a very high unbalanced rural landscape, two more than in 2012, due to the transition of Daia and Malu localities from the high unbalanced rural landscape category to the very high unbalanced rural landscape category.

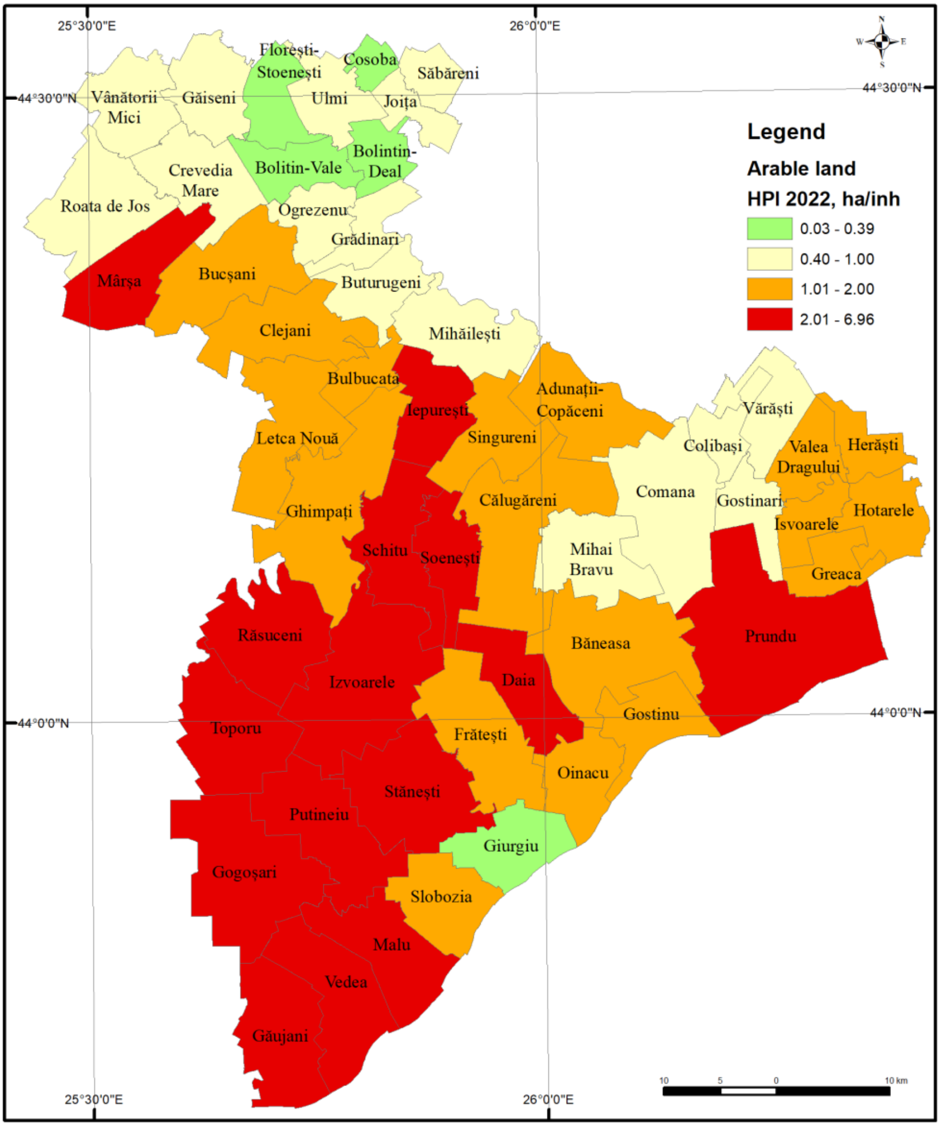

Fig. 8 Values for HPI exerted by arable land in 2022
(Data source: INS)

A very high pressure exerted by arable land was recorded in 2022 at Gogoșari, where the HPI reached a value of 9.96 ha/inh. As in previous years, the urban settlement of Mihăilești displayed only slight signs of landscape disturbance.

4. CONCLUSIONS

Corine Land Cover (CLC) data for the years 1990, 2000, 2006, 2012, 2018 show that the main category of land use across the territory of Giurgiu County is non-irrigated arable land with a percentage of over 60%. Data for the year 2022 also suggests that this category was still the most spread land use category in the year 2022.

Within the western administrative-territorial units of Giurgiu county, considerable environmental stress is exerted due to intensive agricultural land utilization. The main localities affected include: Schitu, Stoenești, Răsuceni, Izvoarele, Toporu, Putineiu, Stănești, Gogoșari, Găujani, Vedea and Malu. Additional pressure points are observed in Mârșa (north), Iepurești and Daia (central) and Prundu (west).

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