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LAND USE AND LAND COVER CHANGES IN THE COLENTINA SUB-BASIN DURING 2000-2018 USING LAND COPERNICUS DATA

Anca-Roxana STRUGARIU, Sevastel MIRCEA

University of Agronomic Sciences and Veterinary Medicine of Bucharest, 59 Mărăşti Blvd, District 1, Bucharest, Romania

Corresponding author email: anca.roxana.strugariu@gmail.com

Abstract

This study analyses land use and land cover dynamics in the Colentina Sub-Basin between 2000 and 2018 using high-resolution Land Copernicus data. The results highlight consistent increases in artificial surfaces, particularly continuous and discontinuous urban fabric, indicating accelerated urban expansion within the watershed. In parallel, agricultural areas recorded a significant decline, suggesting ongoing land conversion processes driven by suburbanisation and infrastructural development. The semi-natural areas remained relatively stable, while wetlands and inland water bodies showed minor fluctuations. These spatial transformations are relevant, as changes in land cover influence ecosystem services, microclimate regulation, surface runoff, and exposure to environmental risks. Understanding these patterns supports integrated planning and provides evidence-based insights for managing green infrastructure, ecological connectivity, and the overall environmental health of the sub-basin.

Key words*: land use, land cover, landscape change, landscape dynamics, Colentina.*

INTRODUCTION

Land use and land cover changes represent some of the most important indicators of landscape transformation, influencing ecosystem services, hydrological processes, biodiversity conservation, and spatial development patterns (Foley et al., 2005; Lambin & Geist, 2006). In rapidly urbanizing regions, the conversion of agricultural and natural land into built-up areas may generate significant environmental pressures and alter the ecological functionality of landscapes (EEA, 2016).

The Bucharest Metropolitan Area has experienced substantial urban growth during the last decades, particularly within peri-urban localities situated along major transportation corridors. These processes have contributed to the expansion of residential, commercial, and infrastructural areas, often at the expense of agricultural land and semi-natural habitats.

Given its strategic position within the metropolitan area and the presence of important aquatic and green infrastructure elements, the Colentina sub-basin represents a relevant case study for assessing long-term territorial transformations.

The Colentina River sub-basin is located in the south-eastern part of Romania, within the Romanian Plain. This region is characterized by lowland relief, with low altitudes and gentle slopes that favour slow water flow and the natural or artificial development of linear water bodies. From an administrative perspective, the Colentina sub-basin extends across two main counties, Ilfov and Dâmbovița, as well as marginal areas of Giurgiu and Călărași, while also covering a significant portion of the territory of Bucharest Municipality.

Within the capital, the river passes through densely urbanized areas and has a direct impact on the urban structure, the green space systems, and the infrastructure for managing stormwater and wastewater.

The Colentina sub-basin is an integral part of the Argeș river basin, one of the most important basins on the southern slope of Romania, which ultimately drains into the Danube River.

Although Colentina is a lower-order tributary, its role is strategic, especially within the Bucharest Metropolitan Area, where it contributes significantly to flow regulation, stormwater collection, and the support of valuable aquatic ecosystems. Its connection to the Argeș hydrographic network is established through the Dâmbovița River, into which Colentina discharges near the locality of Bălăceanca, southeast of the capital.



Figure 1. Positioning of the Colentina sub-basin in relation to the main: a. administrative units (counties); b. natural units (major river basins) (Boundary data sources: ANAR, INS)

The objectives of this study are to quantify changes in land-cover categories during the study period, identify the principal spatial trends related to urban expansion, agricultural land conversion, and assess the implications of these transformations for territorial planning and sustainable land management alongside the Colentina sub-basin.

MATERIALS AND METHODS

This study is based on the analysis of land use and land cover dynamics within the Colentina sub-basin, using data provided by the Copernicus Land Monitoring Service (Land Copernicus).

Land use refers to the set of social, economic, and cultural activities that determine how a piece of land is utilized. This includes, for example, agricultural land, residential areas, industrial zones, transportation networks, or recreational spaces.

According to the Food and Agriculture Organization, land use refers to the activities and interventions through which people manage a specific type of land cover in order to produce, modify, or maintain it (FAO, 1997).

Land cover, on the other hand, refers to the observable physical and biological layer of the Earth's surface, such as forests, grasslands, water bodies, built-up areas, or bare land.

The classification used is based on the CORINE Land Cover (CLC) nomenclature, which adopts a three-level hierarchical structure to describe land use and land cover across Europe.

- Level I includes the most general categories, five in total, representing the major land-use types;
- Level II provides intermediate thematic detail, structured into 15 classes;
- Level III is the most specific level, comprising 44 distinct classes that allow for an in-depth analysis of territorial characteristics.

The Coordination of Information on the Environment (CORINE) inventory provides harmonized land-cover datasets for Europe and includes change layers for four reference periods beginning in 1990. For this study, the CLC datasets for 2000-2018 were downloaded free of charge from the European Environment Agency (EEA, 2019). At the time the study was conducted, the 2018 dataset represented the most recent validated CORINE Land Cover product available for the study area, while the corresponding 2024 dataset had not yet been released. Therefore, 2018 was selected as the final reference year for the analysis.

Spatial data processing and analysis were carried out in QGIS Desktop 3.24, where the datasets were imported, clipped to the boundaries of the Colentina sub-basin, and analysed to assess temporal land use and land cover dynamics. Spatial overlay operations, attribute-based queries, and area calculations were applied to quantify the extent of individual CLC classes and identify transitions between land-cover categories over time.

The resulting thematic maps were produced using QGIS, whereas statistical calculations, summary tables, and charts were prepared in Microsoft Excel to facilitate the analysis and interpretation of landscape transformation patterns throughout the study period.

RESULTS AND DISCUSSIONS

The dynamics of land use and land cover indicate the pace and direction of transformations within the Colentina sub-basin, driven by both anthropogenic pressures and natural or climatic factors. Urban expansion, agricultural restructuring, and shifts in natural and semi-natural areas are clearly reflected in the temporal evolution of the CLC Level I categories. These spatial modifications show how the built environment has expanded, how agricultural land has diminished or changed in function, and how green spaces have been reshaped under development pressure. Such patterns provide essential insights into ecosystem stress and the environmental risks associated with land-use change.

The interpretation of these trends contributes to a deeper understanding of regional planning challenges and the development of sustainable land-management policies. They also underline the need for integrated territorial management in rapidly urbanizing areas, where land-use decisions generate long-term ecological and socio-economic impacts.

Table 1. CLC Code Classification

CLC - I Code	CLC - II Code	CLC - III Code
1 - Artificial surfaces	11 - Urban fabric	111 - Continuous urban fabric
		112 - Discontinuous urban fabric
		121 - Industrial or commercial units
		122 - Road and rail networks and associated land
	12 - Industrial, commercial and transport units	124 - Airports
		133 - Construction sites
		141 - Green urban areas
		142 - Sport and leisure facilities
2 - Agricultural areas	21 - Arable land	211 - Non-irrigated arable land
		221 - Vineyards
	22 - Permanent crops	222 - Fruit trees and berry plantations
	23 - Pastures	231 - Pastures
		242 - Complex cultivation patterns
	24 - Heterogeneous agricultural areas	243 - Land principally occupied by agriculture, with significant areas of natural vegetation
3 - Forest and semi-natural areas	31 - Forests	311 - Broad-leaved forest
		321 - Natural grasslands
	32 - Scrub and/or herbaceous vegetation associations	324 - Transitional woodland-shrub
4 - Wetlands	41 - Inland wetlands	411 - Inland marshes
5 - Inland waters	51 - Inland waters	511 - Water courses
		512 - Water bodies

*Adapted from Bossard et al., 2000.

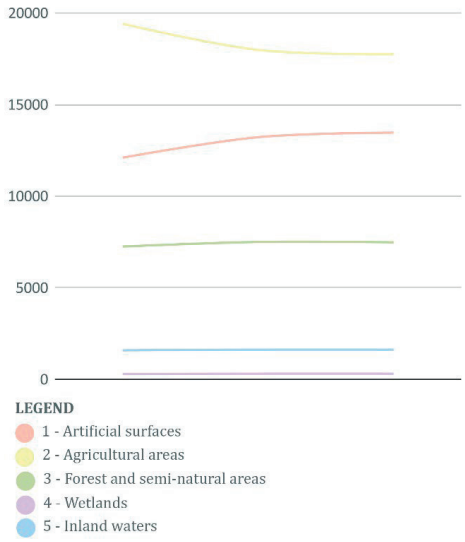
The analysis of land use and land cover dynamics according to the CLC Level I classification for the period 2000-2018 highlights significant transformations across the five major spatial categories. The most evident trend is the steady increase in artificial surfaces, which expanded from 10,854 hectares in 2000 to 13,469 hectares in 2018 (Table 2). This growth reflects accelerated urbanization and the continuous expansion of built-up areas, infrastructure, and anthropogenic functional spaces. The process is indicative of the pressure exerted by urban development on other land-use types, particularly on agricultural areas.

Agricultural zones show a progressive decline throughout the entire period, decreasing from 20,770 hectares in 2000 to 17,752 hectares in 2018. This reduction may be associated, on one hand, with the conversion of agricultural land into built-up areas and, on the other hand, with agricultural abandonment or the reconversion of land into other types of cover, such as natural vegetation or regenerating areas. A gradual loss of agricultural function is clearly visible, with direct implications for food security and local ecological balance.

The category “Forests and semi-natural areas” remained relatively stable, with a slight increase between 2000 and 2012, followed by stabilization in 2018. The surface area of this class fluctuated around 7,200-7,500 hectares, suggesting either natural regeneration in certain areas or the preservation of forest surfaces through conservation policies. Although the changes are not substantial, maintaining balance within this class is particularly important in the context of biodiversity conservation and the role of forests in mitigating climate change.

Although wetlands represent a small share of the total analysed area, they experienced a notable increase between 2000 and 2006, from 185 hectares to 284 hectares, reaching more than 308 hectares in 2018. This trend may be attributed to improved detection of these ecosystems through remote sensing. The maintenance of these surfaces at a relatively stable level between 2006 and 2018 indicates a positive stabilization of wetland ecosystems.

Inland waters recorded a slight increase, from 1,568 hectares in 2000 to 1,616 hectares in 2018. Although the variations are minor, they may reflect changes in the spatial delineation of water bodies, hydrotechnical interventions, or natural fluctuations in the area's hydrological regime. Overall, a clear trend of agricultural land conversion into artificial surfaces can be observed (Figures 2 and 3).



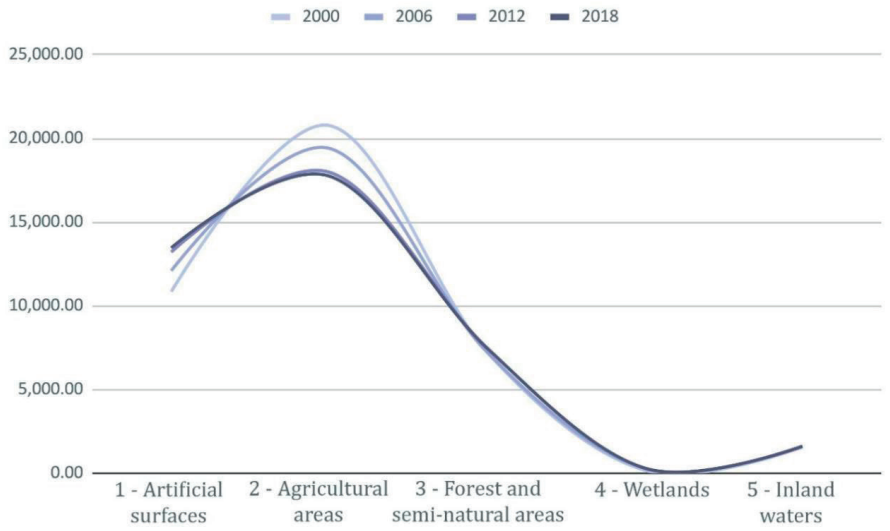


Figure 2. Evolution of the areas corresponding to the main CLC Level I categories during the period 2000-2018

Table 2. Areas resulting from the CLC Level I classification

CLC Code	Land-use category	Area in hectares (ha)/Year*			
		2000	2006	2012	2018
1	Artificial surfaces	10,854.06	12,101.55	13,218.77	13,469.18
2	Agricultural areas	20,770.74	19,410.29	17,984.46	17,752.52
3	Forest and semi-natural areas	7,248.74	7,249.04	7,499.95	7,481.46
4	Wetlands	185.70	284.71	308.39	308.39
5	Inland waters	1,568.72	1,582.40	1,616.47	1,616.47

*Areas in hectares resulting from the GIS analyses.

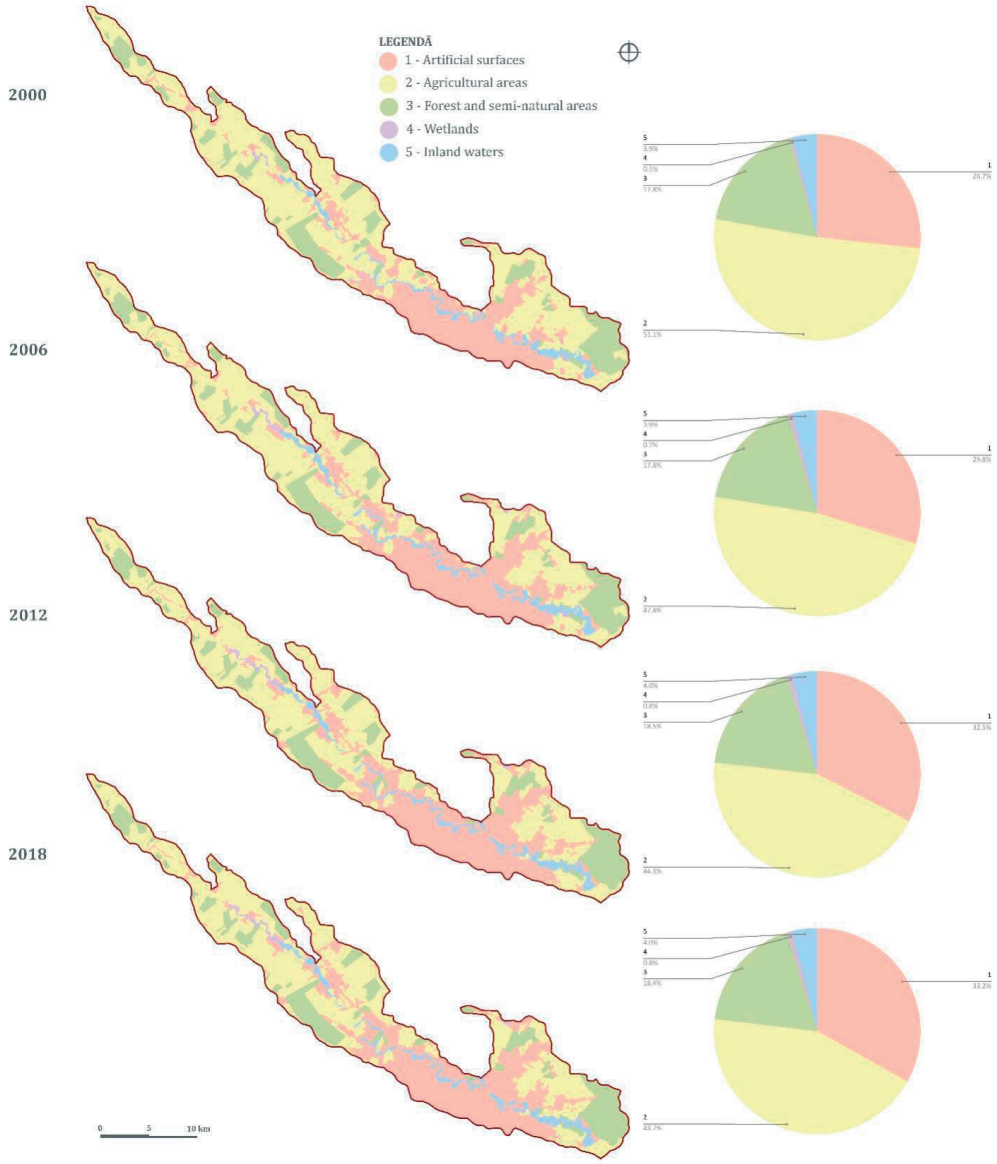


Figure 3. Land use according to CLC Level I codes for the years 2000-2018.
Data retrieved and interpreted from Land Copernicus

The period 2000-2018 is characterized by a clear process of territorial transformation (as shown in Table 3), in which agricultural land gradually loses its share in favour of artificial surfaces.

The increase in continuous urban fabric and the expansion of construction sites reflects the pressure of urbanization, particularly in the vicinity of the Colentina River. At the same time, a gradual decrease in broad-leaved forests is observed, accompanied by the emergence of areas undergoing ecological transition, indicating a structural modification of the vegetated landscape.

Thematic maps and associated pie charts support this spatial interpretation, providing a clear picture of the main land-use types and the changes that have occurred over the past two decades. These modifications reflect both socio-

economic processes, such as the expansion of residential and infrastructural areas, and spatial dynamics influenced by uneven urban development policies.

The reduction of agricultural land and the fragmentation of natural habitats may have consequences for the functionality of local ecosystems, biodiversity, and their capacity to adapt to climate change. Therefore, close monitoring of these trends becomes essential for informing sustainable territorial planning measures and the conservation of natural resources.

The values in the table below confirm a progressive diversification of land-cover patterns, with increasingly complex interactions between urbanized areas, regenerating vegetation, and residual agricultural land, and they highlight the need for coordinated management strategies across the entire sub-basin.

Table 3. Areas resulting from the CLC Level III classification

CLC Code	Land-use category	Area in hectares (ha)/Year*			
		2000	2006	2012	2018
111	Continuous urban fabric	97.90	4,195.95	4,460.14	4,487.66
112	Discontinuous urban fabric	8,083.07	4,395.67	3,811.02	3,869.01
121	Industrial or commercial units	1,568.78	2,405.78	2,171.40	2,211.33
122	Road and rail networks and associated land	267.09	181.76	157.79	157.79
124	Airports	2.76	1.74	1.74	1.74
133	Construction sites		117.09	1,716.52	1,809.33
141	Green urban areas	622.82	511.01	704.59	704.59
142	Sport and leisure facilities	211.64	292.55	195.57	227.73
211	Non-irrigated arable land	18,318.42	16,910.71	12,996.69	13,181.13
221	Vineyards	34.48	34.48		
222	Fruit trees and berry plantations	606.80	808.34	231.32	231.32
231	Pastures	582.41	918.10	3,414.57	2,998.20
242	Complex cultivation patterns	1,164.41	484.18	1,113.51	1,113.50
243	Land principally occupied by agriculture, with significant areas of natural vegetation	64.22	254.48	228.37	228.37
311	Broad-leaved forest	7,196.40	6,910.06	6,587.67	6,304.97
321	Natural grasslands	52.34			
324	Transitional woodland-shrub		338.98	912.28	1,176.49
411	Inland marshes	185.70	284.71	308.39	308.39
511	Water courses	66.41	370.43	335.54	335.54
512	Water bodies	1,502.31	1,211.97	1,280.93	1,280.93

*Areas in hectares resulting from the GIS analyses.

The year **2000** (Figure 4) reflects a clear dominance of agricultural land, particularly non-irrigated arable land (code 211), which occupies more than 18,300 ha, representing approximately 45% of the analysed area. Discontinuous urban fabric (112) is the main form of artificial land use, exceeding 8,000 ha, while continuous urban fabric (111) is almost absent. Forested areas are significant, with broad-leaved forests (311) totalling over 7,100 ha. Wetland and aquatic areas (411, 511, 512) are present in a minor proportion.

This land-use structure reflects a predominantly rural spatial organization, with low levels of anthropogenic pressure and a still balanced presence of natural components.

The distribution of land-use types indicates limited landscape fragmentation, while the high share of agricultural land suggests an economy oriented toward primary activities. The small surface occupied by built-up areas and infrastructure points to an early stage of urban development, likely concentrated around transport nodes or existing traditional

settlements. The year 2000 can be considered a reference baseline for the initial state of the territory, prior to the onset of accelerated urbanization and the functional conversion processes observed in subsequent years.

By **2006** (Figure 5), a radical change can be observed in the occupation of the territory by artificial surfaces. Continuous urban fabric (111) shows explosive growth, reaching more than 4,100 ha, while discontinuous urban fabric (112) decreases significantly.

This pattern is mainly explained by the densification and consolidation of previously dispersed built-up areas, particularly within the Bucharest metropolitan fringe and the rapidly developing settlements of Ilfov County. The conversion of discontinuous urban fabric into continuous urban fabric reflects the expansion of residential developments, commercial areas, and supporting infrastructure, resulting in a more compact urban structure.

In addition, part of this change may be influenced by updates in the CORINE Land Cover classification methodology and improved interpretation of urban land-cover patterns between successive mapping campaigns.

Agricultural land loses more than 1,400 ha, particularly arable areas. These transformations signal the beginning of a new phase in the evolution of the territorial landscape, in which urban pressure becomes visible not only through the expansion of built-up surfaces but also through the progressive fragmentation of natural and agricultural areas. The emergence of class 133 (construction sites) serves as an indirect indicator of intensified functional conversion processes and changes in land use, especially near mobility corridors or highly accessible areas. At the same time, the appearance of transitional woodland-shrub (324) suggests an intermediate stage in the ecological reconfiguration of the territory.

This year marks a stage of imbalance between artificial development and the conservation of natural resources, with direct implications for the ecological and functional structure.

In **2012** (Figure 6), the trends already outlined in previous years continue: urban areas keep expanding, while agricultural surfaces continue to decrease. A massive expansion of construction sites (133) is observed, exceeding 1,700 ha, a clear indicator of intensified real estate and infrastructural development.

The area of broad-leaved forests (311) decreases to below 6,600 ha, but an increase in class 324 (transitional woodland-shrub) is recorded, suggesting active vegetation regeneration processes.

This redistribution of land-cover categories reflects an intensification of spatial transformations, in which the expansion of built-up areas occurs simultaneously with reconfigurations in marginal or less productive lands. The increase in pastures (231) may indicate either a temporary functional reallocation of land removed from intensive agricultural use or the spontaneous development of vegetation in abandoned or less accessible areas. The decline in mature forests is partially offset by the emergence of regenerating surfaces (324), highlighting an ongoing ecological transition. Furthermore, the sustained development of built-up areas indicates a favourable context for continued urban expansion, while natural and agricultural spaces tend to become increasingly fragmented or subject to indirect pressures.

By **2018** (Figure 7), the urbanization process appears to continue at a steady yet more stabilized pace. Continuous urban fabric (111) reaches nearly 4,500 ha, while construction sites remain a significant component (over 1,800 ha). Arable land remains low compared to the year 2000, confirming the gradual conversion of these areas to other land uses. Broad-leaved forests (311) continue to decline slightly, while transitional woodland-shrub (324) reaches a historical maximum of over 1,100 ha.

The decline of non-irrigated arable land is primarily associated with the expansion of residential areas, industrial and commercial developments, transport infrastructure, and construction sites. These changes are particularly evident in the peri-urban areas surrounding Bucharest, where agricultural land has been progressively converted to urban functions as a consequence of suburbanization and increasing development pressure.

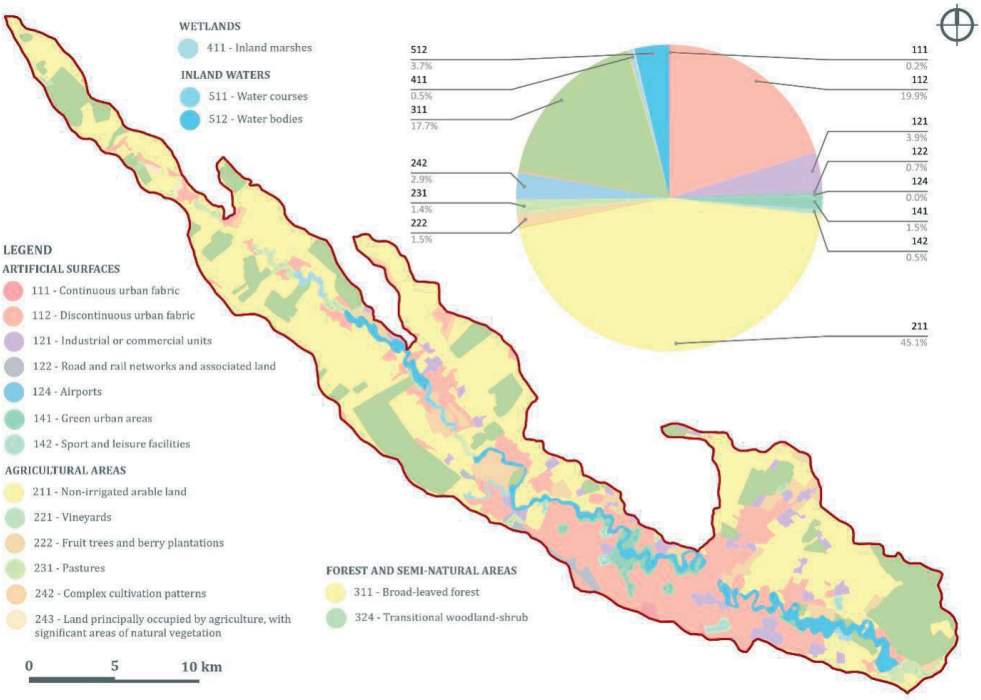


Figure 4. Land use - year 2000, according to the CLC Level III classification. Data retrieved and interpreted from Land Copernicus

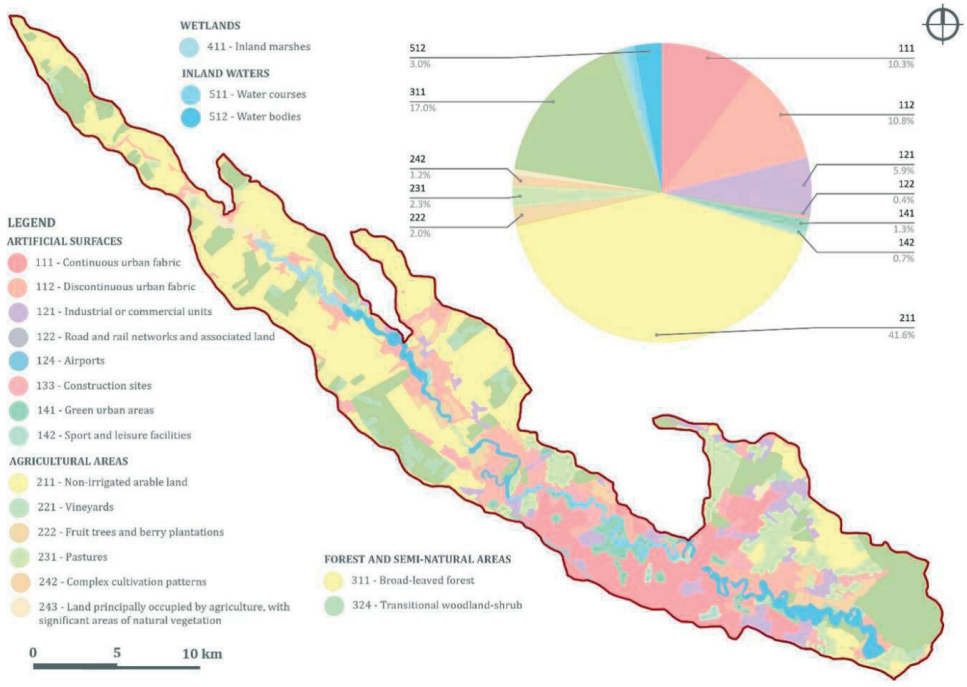


Figure 5. Land use - 2006, according to CLC Level III classification. Data were retrieved and interpreted from Copernicus Land Copernicus

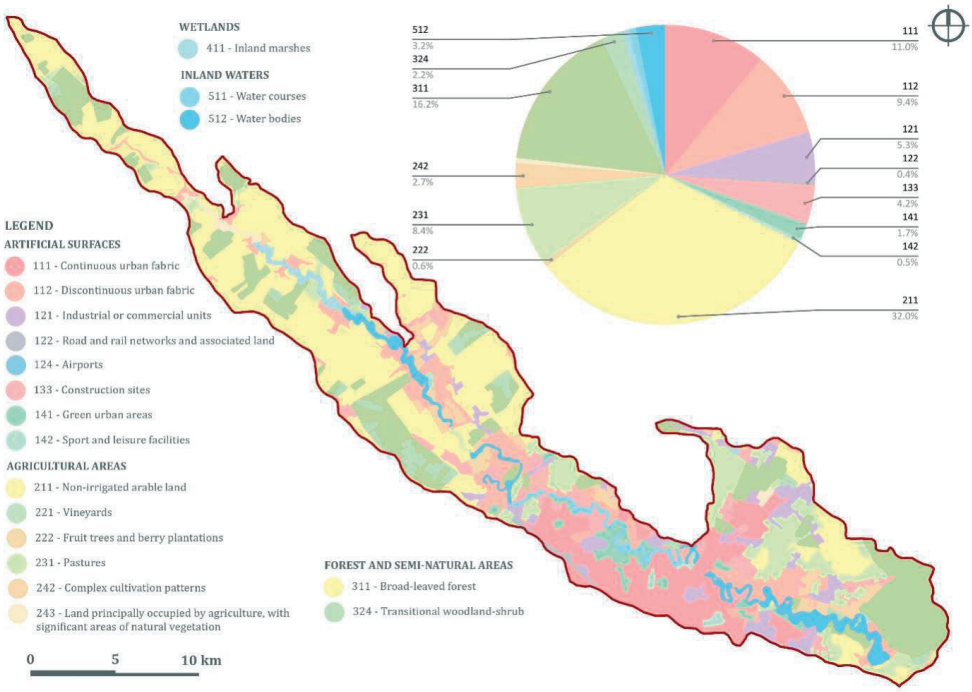


Figure 6. Land use - 2012, according to CLC Level III classification. Data retrieved and interpreted from Land Copernicus

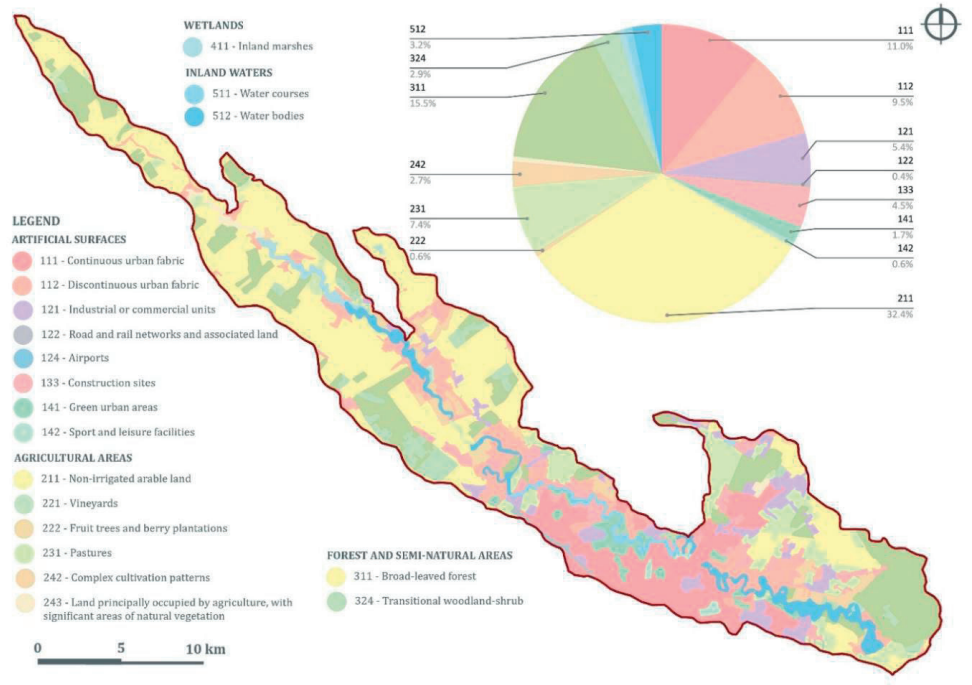


Figure 7. Land use - year 2018, according to CLC Level III classification.
Data retrieved and interpreted from Land Copernicus

The persistence of construction sites indicates that urban expansion has not ceased but is in a phase of consolidation and localized extension. Likewise, the balance between the loss of mature forests and the emergence of transitional vegetation suggests a functional reconfiguration of ecosystems, possibly driven by planned interventions or uncontrolled natural processes.

The year 2018 highlights a stage of maturation within the urbanization process, where transformations become more subtle but exert a significant cumulative impact on the landscape and on the territory's capacity to provide ecosystem services.

The percentage variation of land-cover categories between 2000 and 2018, presented in Table 4, illustrates the main territorial transformations within the study area.

The largest increases occur in continuous urban fabric and construction sites, indicating strong urban expansion. Growth in pastures and transitional woodland-shrub also reflects ecological regeneration or land abandonment. In contrast, notable decreases in discontinuous urban fabric and non-irrigated arable land suggest a continued decline in traditional agricultural uses.

Table 4. Percentage change for 2000-2018 in CLC Level III categories

CLC Code	Land-use category	Area in hectares (ha)/Year*		Percentage change (%)
		2000	2018	2000-2018
111	Continuous urban fabric	97.90	4,487.66	+4483.92%
112	Discontinuous urban fabric	8,083.07	3,869.01	–52.13%
121	Industrial or commercial units	1,568.78	2,211.33	+40.96%
122	Road and rail networks and associated land	267.09	157.79	–40.92%
124	Airports	2.76	1.74	–36.96%
133	Construction sites		1,809.33	n.a. **
141	Green urban areas	622.82	704.59	+13.13%
142	Sport and leisure facilities	211.64	227.73	+7.60%
211	Non-irrigated arable land	18,318.42	13,181.13	–28.04%
221	Vineyards	34.48		−100.00%
222	Fruit trees and berry plantations	606.80	231.32	–61.88%
231	Pastures	582.41	2,998.20	+414.79%
242	Complex cultivation patterns	1,164.41	1,113.50	–4.37%
243	Land principally occupied by agriculture, with significant areas of natural vegetation	64.22	228.37	+255.61%
311	Broad-leaved forest	7,196.40	6,304.97	–12.39%
321	Natural grasslands	52.34		−100.00%
324	Transitional woodland-shrub		1,176.49	n.a. **
411	Inland marshes	185.70	308.39	+66.07%
511	Water courses	66.41	335.54	+405.25%
512	Water bodies	1,502.31	1,280.93	–14.74%

*Areas in hectares resulting from the GIS analyses.
**Not applicable. Percentage change could not be calculated because the category was absent in the baseline year (2000).

CONCLUSIONS

The analysis of land use and land cover dynamics within the Colentina sub-basin for the period 2000-2018 reveals a significant transformation of the territorial structure. The most evident trend is the expansion of artificial surfaces, driven by rapid and persistent urbanization, which has reshaped the spatial configuration of the area. At the same time, the continuous decline of non-irrigated arable land highlights the gradual reduction of traditional agricultural functions, largely replaced by residential, infrastructural, or transitional landscape uses.

Natural and semi-natural areas show a mixed evolution: while mature forests register a slight decrease, transitional woodland-shrub and

pastures increase considerably, indicating both ecological regeneration and possible land abandonment processes. These shifts contribute to a more fragmented landscape, marked by frequent transitions between built-up zones, regenerating vegetation, and residual agricultural parcels.

In summary, the changes observed during the 18-year interval underline the need for integrated territorial planning that balances urban development with the preservation of ecological functionality. Monitoring land-cover dynamics, especially in rapidly urbanizing regions, is essential for supporting sustainable land-management strategies and enhancing the resilience of ecosystems in the face of ongoing environmental and climatic pressures.

Beyond documenting the magnitude of land-use and land-cover changes, this study demonstrates the applicability of Copernicus Land Monitoring Service datasets and GIS-based analysis for assessing landscape dynamics at the sub-basin scale. The generated spatial database and quantitative indicators provide a replicable methodological framework that can support territorial planning, land-use monitoring, and environmental management in rapidly urbanizing peri-urban areas.

By identifying the main directions of landscape transformation, the results offer a scientific basis for future planning decisions aimed at limiting uncontrolled urban expansion and promoting sustainable land-use practices.

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