LAND USE AND GREEN SPACE ANALYSIS USING REMOTE SENSING AND GIS TECHNIQUES IN THE SUBCARPATHIANS VÂLCII, SOUTH-WEST OLTENIA REGION, ROMANIA

DRĂGULEASA Ionuț-Adrian, CIOBOIU Olivia, MĂCEȘEANU Daniela Mihaela, ALEXANDRU Anca Florentina, ZAHARIA Alexandra Lucia

Abstract. The spatio-temporal analyses are based on Corine Land Cover data and land fund data from the National Institute of Statistics, processed using Geographic Information Systems and Microsoft Excel methods. The land use pattern in the Subcarpathian Valley and the South-West Oltenia Region, Romania, is very important for the implementation stage of the Sustainable Development Goals (SDGs) of the 2030 Agenda. We extracted green spaces and land use data for the South-West Oltenia Region from Landsat 5 TM satellite images (26.05.2000–30.08.2000), Landsat 7 ETM+ satellite images (26.05.2012–30.08.2012), Landsat 8 OLI/TIRS satellite images (23.05.2022–28.08.2022) (USGS), and Corine Land Cover (CLC) (Copernicus Monitoring Service) for the years 2000, 2012, and 2018. The purpose of this study is to analyze land use in the Subcarpathians Vâlcii from 1990 to 2018 using cartographic information and Corine Land Cover, and to examine changes in land use and green spaces using satellite images in the South-West Oltenia Region, as well as other available databases, such as the National Institute of Statistics (NIS).

Keywords: Corine Land Cover, Land use, GIS, Satellite images, Green spaces.

Rezumat. Utilizarea terenului și analiza spațiului verde folosind teledetecția și tehnici GIS în Subcarpații Vâlcii, Regiunea Sud-Vest Oltenia, România. Analizele spatio-temporale se bazează pe date Corine Land Cover și date privind fondul funciar de la Institutul Național de Statistică, prelucrate prin metode ale Sistemelor Informaționale Geografice și Microsoft Excel. Modul de utilizare a terenurilor în Subcarpații Vâlcii și Regiunea Sud-Vest Oltenia, România este foarte important pentru stadiul implementării Obiectivelor de Dezvoltare Durabilă (ODD) ale Agendei 2030. Pentru extragerea spațiilor verzi și a utilizării terenului din Regiunea Sud-Vest Oltenia, am folosit imagini satelitare Landsat 5 TM (26.05.2000–30.08.2000), imagini satelitare Landsat 7 ETM+ (26.05.2012–30.08.2012), imagini satelitare Landsat 8 OLI/TIRS (23.05.2022–28.08.2022) (USGS) și Corine Land Cover (CLC) (Copernicus Monitoring Service) din anii 2000, 2012 și 2018. Scopul cercetării științifice este de a analiza utilizarea terenurilor în Subcarpații Vâlcii, din 1990 până în 2018, folosind informații cartografice și Corine Land Cover, și de a examina schimbări în modul de utilizare a terenurilor și a spațiilor verzi cu ajutorul imaginilor satelitare din Regiunea Sud-Vest Oltenia, precum și a altor baze de date disponibile, precum Institutul Național de Statistică (INS).

Cuvinte cheie: acoperirea terenului Corine, modul de utilizare a terenului, GIS, imagini satelitare, spații verzi.

INTRODUCTION

Remote sensing (RS) and Geographic Information System (GIS) are the most powerful tools for obtaining the most accurate (precise), detailed, and timely information on the spatial distribution of changes in land use/cover over (LULC) large areas (CARLSON & SANCHEZ-AZOFEIFA, 1999; GUERSCHMAN et al., 2003; ROGAN & CHEN, 2004; DEZSO et al., 2005; SANDU & GROZA, 2017; BIELECKA, 2020; OLORUNFEMI et al., 2020; WANG et al., 2020; WIATKOWSKA et al., 2021; ZHANG et al., 2020), which in our case comprises a relief unit—the Subcarpathians Vâlcii—and a Development Region—the South-West Oltenia Region, Romania.

GIS provides a flexible environment for collecting, storing, displaying, visualizing, and analyzing digital data needed for change detection (WU et al., 2006; REIS, 2008; CONSTANTINESCU et al., 2023; DRĂGULEASA et al., 2023). On the one hand, remote sensing images represent the most important data resources of Geographic Information Systems. On the other hand, they are used to recognize synoptic data of the Earth's surface (ULBRICHT & HECKENDORFF, 1998).

According to NATH et al. (2018), the NW-SW areas of the United States of America (USA) are experiencing particularly high rates of LULC change, with significant declines in agriculture and forest areas. Remote sensing data have been widely used to estimate continuous LULC changes in the USA for 1973–2000 (SLEETER et al., 2013) and 1973–2010 (SLEETER et al., 2018).

Land use and land cover change (LULC) is the most obvious indicator of changes on the Earth's surface (KOSCHKE et al., 2012; PHAN et al., 2020) that affect the provision of ecosystem services, posing a challenge to achieving sustainable development (AOUISSI et al., 2021; JI et al., 2021). Tourism is widely recognized as key to achieving the 17 United Nations Sustainable Development Goals (SDGs) and their 169 associated targets (ABDOU et al., 2020).

The 17 Sustainable Development Goals, as highlighted in Figure 1, are defined by (***. https://www.un.org/sustainabledevelopment/sustainable-development-goals/) as representing "*the blueprint for achieving a better and more sustainable future for all. The SDGs address the global challenges we face, including poverty, inequality, climate change, environmental degradation, peace and justice*."

Figure 1. The Sustainable Development Goals.
Source: ***. https://www.un.org/sustainabledevelopment/sustainable-development-goals/.

Due to the social and physical characteristics of communities, the distribution of land changes and land cover varies in time and space (AMINI et al., 2022). According to the most recent studies in the literature, LULC change can show the negative effects of various environmental and socio-economic factors on the Earth's surface, including climate, water balance, plant and animal biodiversity, and terrestrial ecosystems (BEER et al., 2010; STERLING et al., 2013; SALAZAR et al., 2015). Among these factors, the impact of land use and land cover (LULC) on the ecosystem has become the most attractive research topic (KOSCHKE et al., 2012; PAN et al., 2011; REICHSTEIN et al., 2013; AHLSTRÖM et al., 2015; AMANI et al., 2020).

Therefore, modern 21st-century planning is based on geospatial data and analyses of land cover and land use dynamics to determine trends or developments and even make medium and long-term forecasts (POPOVICI et al., 2018; KUCSICSA et al., 2020; NOBY et al., 2023; MU et al., 2024; ZHU et al., 2024). Most often, such data are used in conjunction with a Geographic Information System (GIS), defined as "*decision support systems that involve the integration of spatially referenced data into a problem-solving environment*" (COWEN, 1988). According to PETRIȘOR et al. (2025), the ultimate goal of a Geographic Information System is not simply to map reality, but to use maps to solve real-life problems, such as those faced with land use planning or green infrastructure. At the same time, the spatio-temporal representation of the use of land and green spaces is the product of the processing, organization, and graphic translation of perceived spatial elements (TRIPONESCU et al., 2024; DRĂGAN et al., 2025).

In the study "*Evaluation of land use changes and landscape fragmentation in the Cacica and Vatra Dornei tourist area*", the authors Horodnic et al. (2019a) used ArcGIS 10.2.2 software to analyze the spatial distribution of land use changes over 22 years (1990–2012). This analysis was possible thanks to the processing of data provided by the European CORINE Land Cover project.

The purpose of this study is to analyze land use in the Subcarpathians Vâlcii from 1990 to 2018 using cartographic information and Corine Land Cover, and to examine land use and green spaces using satellite images in the South-West Oltenia Region, as well as other available databases, such as the National Institute of Statistics (NIS).

The research objectives of the study are (1) to provide a set of continuous annual land use/cover maps of the Subcarpathians Vâlcii, Romania, and (2) to analyze the dynamics of land use/cover and green spaces in the South-West Oltenia Region, Romania. The maps generated during this study can provide a foundation for research on other key scientific questions related to the land system and ecological changes in the Subcarpathians Vâlcii, Romania.

MATERIALS & METHODOLOGY

Field of study. A subdivision of the Getic Subcarpathians, the Vâlcii Subcarpathians are located in the southern part of the country (Fig. 2), on both sides of the Olt River, and constitute one of the oldest settlements in Romania. Mentioned in documents written as early as January 1392, in a charter of Mircea the Elder, the Vâlcii study area appears as a relief step between the mountains and the lowlands outside them, being made up of an association of hilly peaks separated by valleys or depressions (ROANGHEȘ-MUREANU, 2012, p. 51).

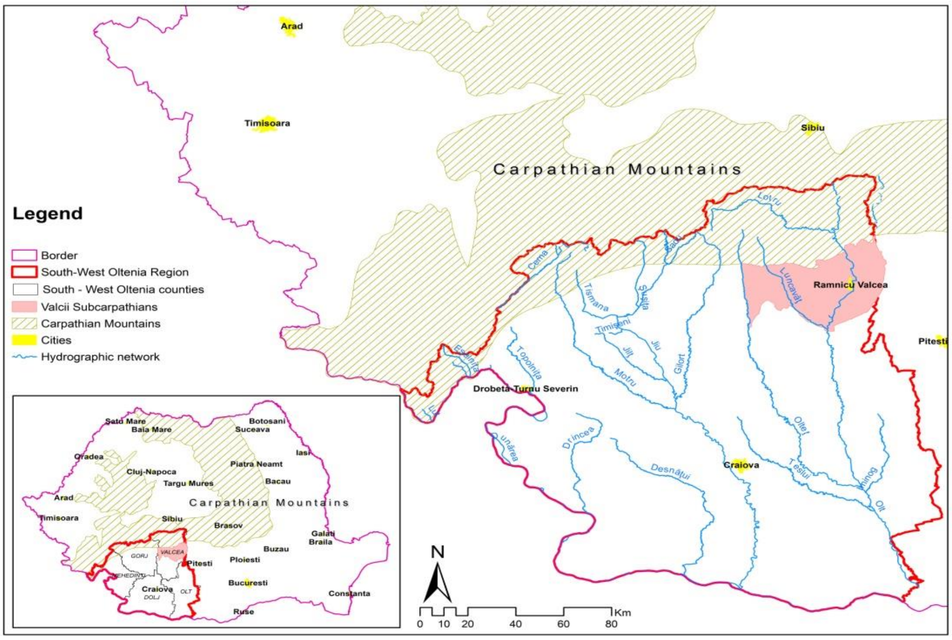

Figure 2. Location of the Subcarpathians of the Vâlcii in regional and national contexts.
Source: author-processed data using ArcGIS 10.7.2.

According to ROȘU (1980, pp. 389-390), the Vâlcii Subcarpathians are located "*between Bistrița Vâlcii and Gilort, corresponding to the area of the subcarpathian folds, they are made up of a single subcarpathian corridor: Hurez-Polovragi-Novaci and a single row of subcarpathian hills: Măgura Slătioarei (267 m), Dealul Grecilor (594 m), Dealul Muierii (561 m), Dealul Cîrligeilor (536 m), Dealul Seciului (597 m). The subcarpathian contact with the Getic Plateau in the south is achieved through a depressional erosion corridor: Matești-Becheni-Zorlești, with the exception of the tectonic Zorlești Depression, which is located at the beginning of the external subcarpathian depressional corridor in the west of Gilort, Cărbunești-Târgu Jiu*".

According to IELENICZ et al. (2003, p. 214), the Vâlcii Subcarpathians "*extend from Topolog to Bistrița, east of Olt under the steeps of the Cozia Mountains there is a wider Jiblea depression through which connections are made with Țara Loviștei, west of Olt it continues with several depression basins (the most significant are Muereasca, Olănești, Bărbătești, etc.) in which there are villages specialized in animal husbandry. To the south where the folded structure on several anticlines and synclines clearly appears, small depressions (Govora, Ocnele Mari) have developed in the soft rocks as a result of differential erosion (especially at the contact with the Getic Plateau)*".

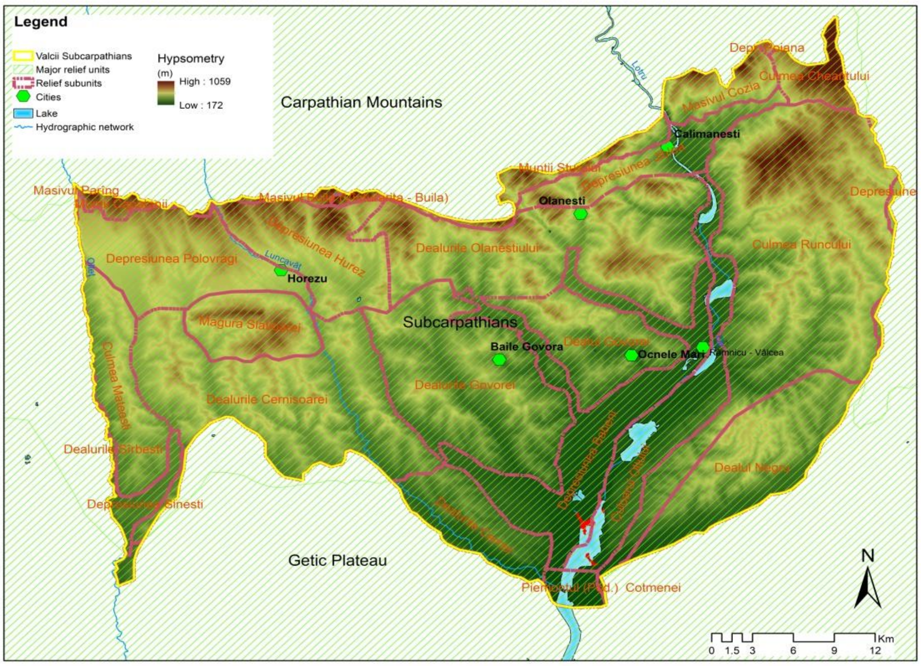

Figure 3. Map of relief units and subunits. Source: author-processed data using ArcGIS 10.7.2.

In addition to the specific limits of the natural environment, such as relief steps, hypsometry, and hydrographic network (Fig. 3), we encounter in the Vâlcea Subcarpathians the anthropogenic limits resulting from the administrative–territorial division (Fig. 4), which mainly includes Vâlcea County and a small part of Argeș and Gorj Counties (ROANGHEȘ-MUREANU, 2012, p. 53). Thus, the study area includes 1 municipality, 7 towns, and 45 communes.

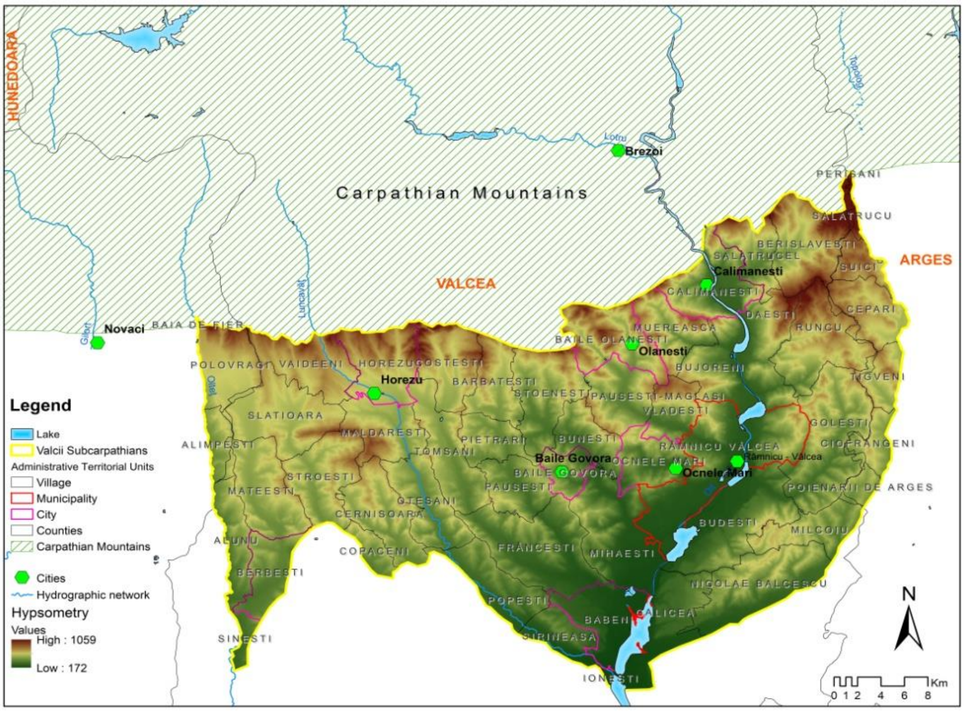

Figure 4. Administrative–territorial units in the Subcarpathians of Vâlcea. Source: author-processed data using ArcGIS 10.7.2.

The hypsometric interval is analyzed to highlight its importance in land use analysis. Hypsometric steps can also condition the different distributions of humanization, viewed through the perspective of population and rural or urban settlements (Fig. 5).

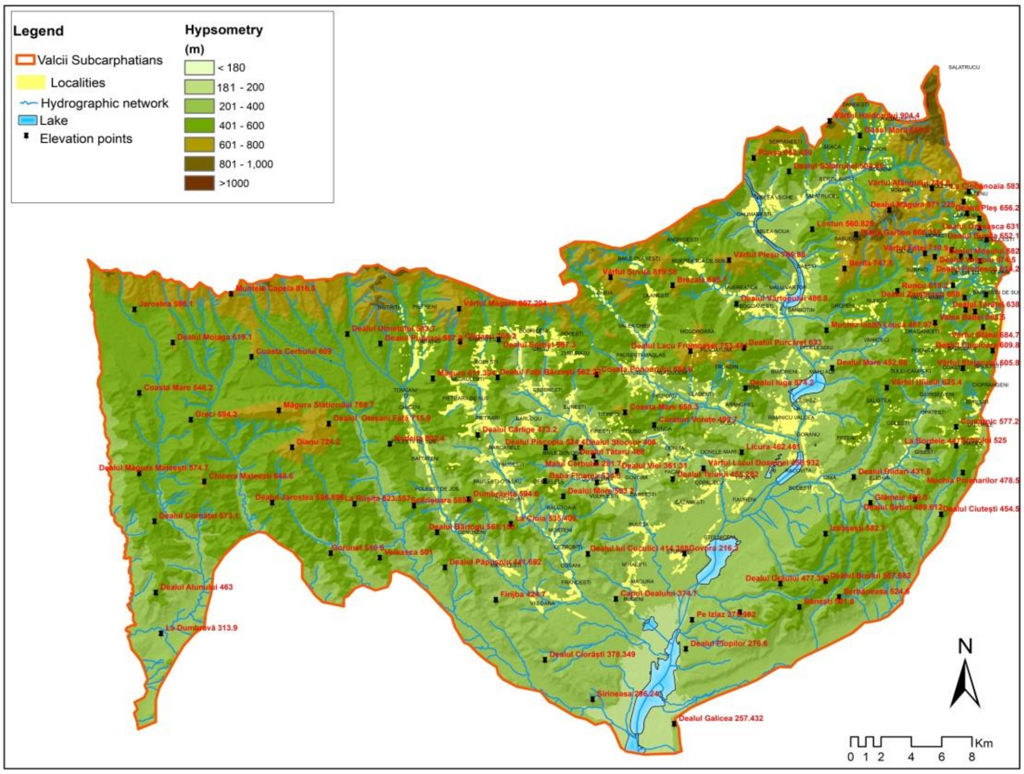

Figure 5. Hypsometric map of the Subcarpathians Vâlcii. Source: author-processed data using ArcGIS 10.7.2.

The climate of the Subcarpathians of the Vâlcii is also greatly influenced by their position, by their location under the shelter of the Southern Carpathians, and implicitly by the forested mountains from which fresh waves of cold air descend in the summer, as well as by the Olt valley which carries cold snowy air in the winter. It is also under the influence of the depressions located on both sides of the river, which provide mild shade against both the winter frost and summer heat. Therefore, the area has a temperate continental climate influenced by the difference in the 300–500 m height level in the south and the valley corridors in the north–south direction (ROANGHEȘ-MUREANU, 2012, p. 69).

The current hydrographic network draining the Vâlcea Subcarpathians belongs to the Olt basin. The rivers in the west are oriented north–south; however, due to a slight tectonic depression, the rivers in the Vâlcea area are diverted to the southeast near the Olt. This inclination is also highlighted by a gradual and general decrease in altitude from west to east.

Nature reserves represent a determining point in clarifying the biopedogeographic conditions that characterize the Subcarpathians Vâlcii, constituting a point of attraction for visitors and foreign tourists. These include the Pyramids on Valea Stăncioiului Geomorphological Reserve, the Mosoroasa Swamp Nature Reserve, the Golești Paleontological Reserve, the Trovanții from Costești, Cozia National Park, Buila-Vânturarița National Park, Olteț Gorges, Ocnele Mari Reserve, Liliecilor Cave etc. (Fig. 6).

Enhancing tourist attractions, i.e., protected areas/natural reserves in the Subcarpathians of the Vâlcii (Fig. 6), would increase interest in spa tourism, rural tourism, agrotourism, ecotourism, and geotourism, and offer an opportunity for economic activity through the development of new jobs, thus decreasing unemployment in the study area.

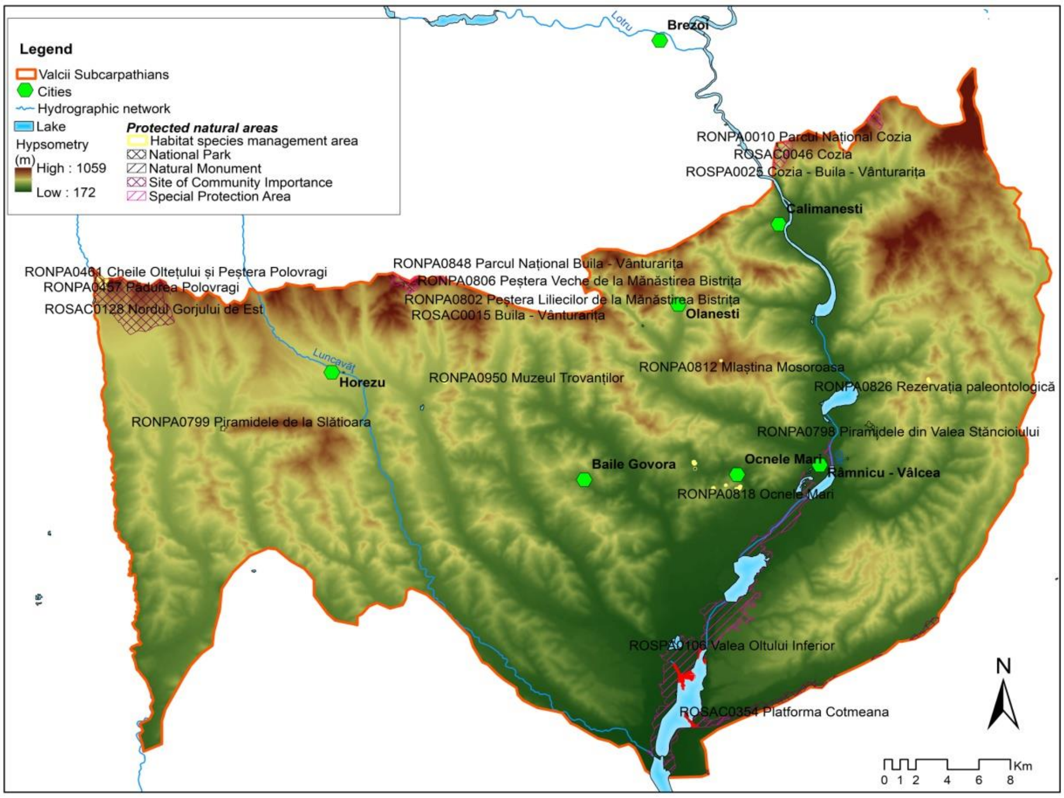

Figure 6. Map of reserves/protected areas of the Subcarpathians Vâlcii. Source: author-processed data using ArcGIS 10.7.2.

Methods, source and gathering of statistical data. CORINE data are particularly useful for assessing land changes over extremely large areas over long periods (PETRIȘOR, 2012). Taking into account the spatio-temporal dimension of urban processes, such as urbanization, deurbanization, and urban restructuring, as well as industrial processes, such as natural resource exploitation (PETRIȘOR et al., 2010), the data from the Coordination of Environmental Information Program (CORINE) provide a complex and detailed picture of the dynamics of land cover or use in territorial statistical units–administrative units in Subcarpathians Vâlcii, Romania, and development regions.

Urbanization, socio-economic development, expansion of transport networks, and land use change (POPESCU et al., 2022; COCHECI & PETRIȘOR, 2023; TACHE et al., 2024) are key factors that cause habitat fragmentation and landscape degradation specific to the natural environment within the Subcarpathians Vâlcii (Romania), reducing connectivity and thus creating artificial barriers along wildlife routes (SMERALDO et al., 2020; NADAL et al., 2022).

To create the Corine Land Cover CLC (1990, 2012, 2018) land use map of the Subcarpathians Valley, we used the following databases: to represent the relief (hillshade), we used ASTER GDEM, version 2 (***. https://geo-spatial.org/vechi/blog/aster-gdem-versiunea-2). The Corine Land Cover land use (CLC 1990, CLC 2012, CLC 2018) was downloaded from the Copernicus website (***. https://land.copernicus.eu/pan-european/corine-land-cover), and satellite images were downloaded from the EarthExplorer website ***. https://earthexplorer.usgs.gov/. The maps contain all the specific elements, which were processed in the program as follows: View—Layout View—Insert: Title, Legend, Scale Bar, Text, etc. The resulting map was exported using File—Export Map, and the saving destination and format (jpg) were chosen (CURCAN et al., 2023). Data reprojection to Stereo 1970 was a mandatory step for the use of the data and the production of suggestive land use maps for the Subcarpathians of Vâlci, Romania (PETRIȘOR et al., 2014; PETRIȘOR & PETRIȘOR, 2018; Petrişor et al., 2020a, b; PETRIȘOR & PETRIȘOR, 2021).

ArcMap 10.7.2 software was useful as a means of spatio-temporal representation and analysis using a Geographic Information System (DRĂGAN et al., 2024a; ROTARU et al., 2024). Representation of statistical data, presentation, exploratory analysis, and interpretation of the obtained results are key aspects to apply, firstly, a cartographic approach to highlight the spatio-temporal pattern of land use/cover changes that occurred in the study area, and secondly, the statistical and graphical approach used to present the data (HORODNIC et al., 2019b).

The following methods were used to create the maps: Clip Tool, which is found in the Geoprocessing menu, was used to cut shapefiles to the desired size and scale; Project Tool was used to transform CLC 1990, CLC 2012, and CLC 2018 data from ETRS 1989 LAEA into Stereo70. This tool is found in the following mode: Data Management Tools—Projections and Transformations—Project.

In the attribute table of the CLC land use type (1990, 2012, 2018), we introduced the field areal_ha, which contains the areas of the land use types. These were calculated using Calculate Geometry and the areas are expressed in hectares. The attribute table was exported using the Export tool in the attribute table. The codes and names for the CLC classes 1990/2012 and 2018 are presented in Table 1.

Table 1. Codes and names for CLC classes.

Codes_90/2018	Class name
112	Discontinuous urban space
121	Industrial or commercial units
122	Network of communication routes and associated lands
131	Ore mining areas
132	Landfills
133	Construction areas
142	Sports and leisure facilities
211	Non-irrigated arable land
221	Vineyards
222	Plantations of fruit trees and shrubs
231	Grassland/Pastures
242	Areas of complex cultures
243	Predominantly agricultural lands
311	Deciduous forests
312	Coniferous forests
313	Mixed forests
321	Natural meadows
324	Forest–reed transition
331	Beaches, dunes, sands
332	Rocks/rock
411	Inland marshes
511	Water courses
512	Bodies of water

We must not overlook the fact that land use classes are closely linked to local, regional, and national climatic conditions (Table 1), demonstrating the delicate interaction between natural elements of the environment and human activity (KALNAY & CAI, 2003; FOLEY et al., 2005; SĂVAN et al., 2024; YAHAYA et al., 2024). However, climatic variables, such as temperature, precipitation, air pressure, wind, and seasonal patterns, have an extremely significant impact on the dynamics, distribution, and components of different land uses (Prăvălie et al., 2013; 2022; PATRICHE & IRIMIA, 2022), including agricultural areas (ADAMS et al., 1998; HOWDEN et al., 2007; AGOVINO et al., 2019; MALHI et al., 2021), forests (ZORAN et al., 2016; MIHAI et al., 2022), and urban spaces and water bodies (STRINGER et al., 2009; RUSU et al., 2014; LI et al., 2019). These climatic variables play a key role in determining the suitability of certain regions for different land uses, positively influencing crop growth, forest density, and the availability of water reserves (RUSU & MORARU, 2015; CHEVAL et al., 2020).

RESULTS & DISCUSSIONS

The 1990 Subcarpathians Vâlcii land use data show that the largest areas were occupied by deciduous forests, fruit tree and shrub plantations, discontinuous urban spaces, non-irrigated arable land, predominantly agricultural land, and areas of complex crops (Fig. 7). The smallest areas (under 100 hectares) were occupied by rocks, construction areas, and sports and leisure facilities (only 15 hectares). The difference in land use between the year 1990 and the years 2012 and 2018 is remarkable, with 1990 having no poorly vegetated areas.

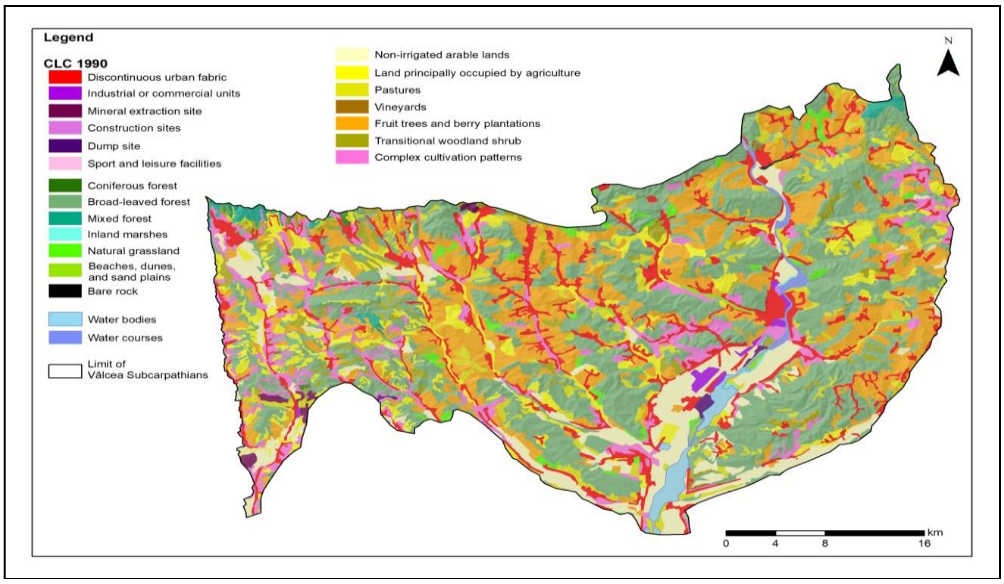

Figure 7. Land use pattern in the Subcarpathians Vâlcii in 1990. Source: author-processed CORINE Land Cover data.

A comparative analysis between 2012 and 2018 indicated increases in land use for the following CLC classes (Fig. 8): mineral extraction areas, fruit tree and shrub plantations, deciduous forests, and mixed forests.

Analysis of land use dynamics is extremely useful for planners as it can inform the best decisions regarding the sustainable development of urban areas (HORODNIC et al., 2018); in our case, these are Călimănești, Băile Olănești, Ocnele Mari, Băile Govora, Costești, Horezu, and Râmnicu Vâlcea.

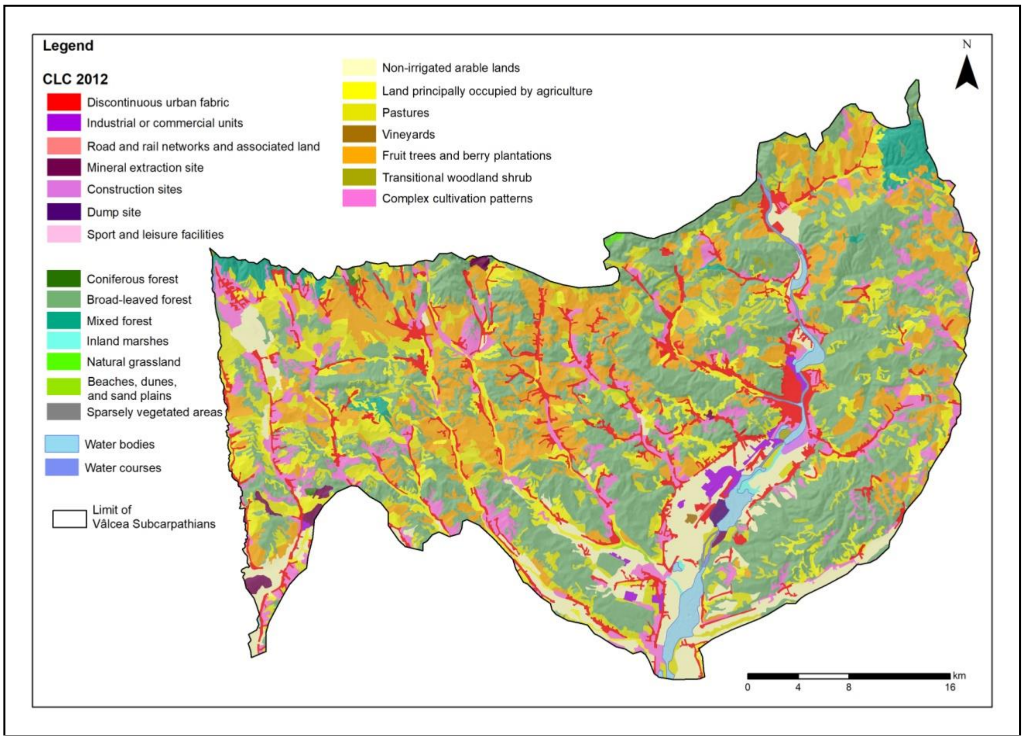

Figure 8. Land use pattern in the Subcarpathians Vâlcii in 2012. Source: author-processed CORINE Land Cover data.

Analysis of the statistical data for land use in 2018 (Fig. 9) shows that deciduous forests predominate, followed by fruit tree and shrub plantations, pastures, predominantly agricultural lands, complex crop areas, discontinuous urban spaces, and non-irrigated arable lands. In 2018, the smallest areas were those occupied by natural meadows, vineyards, networks of communication routes and associated lands, sports and leisure facilities, and sparsely vegetated areas.

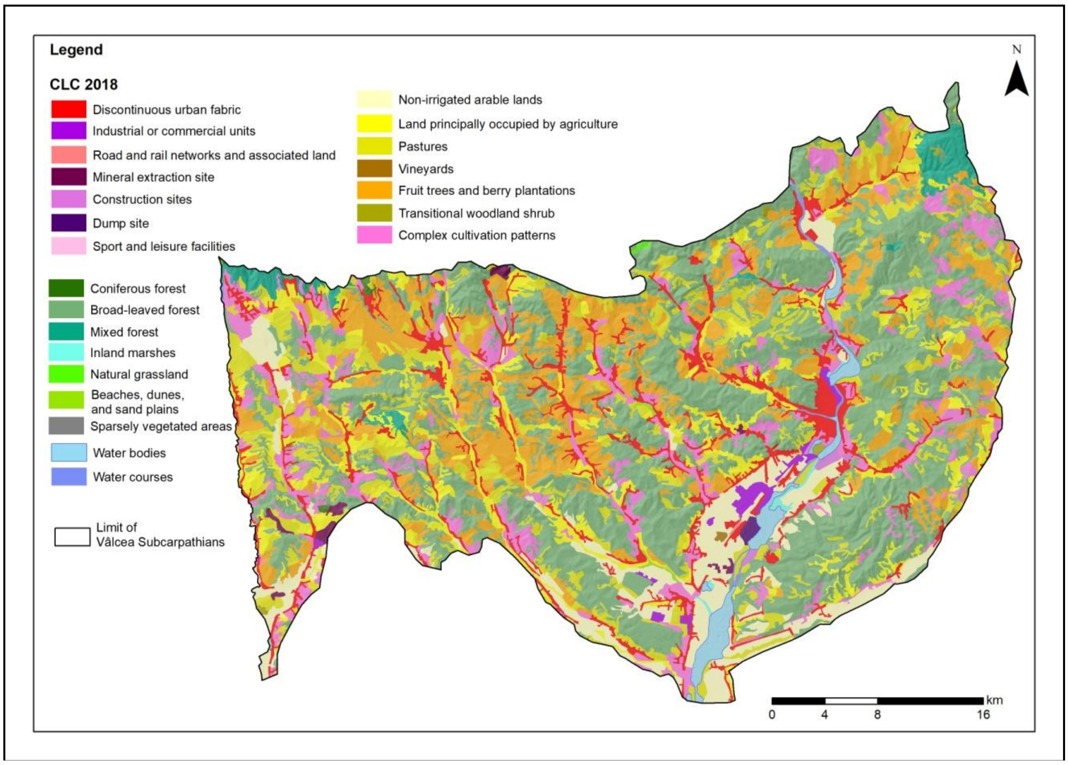

Figure 9. Land use pattern in the Subcarpathians Valley in 2018. Source: author-processed CORINE Land Cover data.

The maps above are complemented by column graphs/diagrams showing the differences between the three periods analyzed. In 2012, unlike 1990 (Fig. 10), notable differences were recorded in classes 112 (discontinuous urban space), 222 (fruit tree and shrub plantations), 231 (pastures), 311 (deciduous forests), and 324 (forest–reedbed transition). Differences were also recorded between 2012 and 2018 and between 1990 (first year analyzed) and 2018 (last year analyzed). Figures 11 and 12 graphically depict these differences.

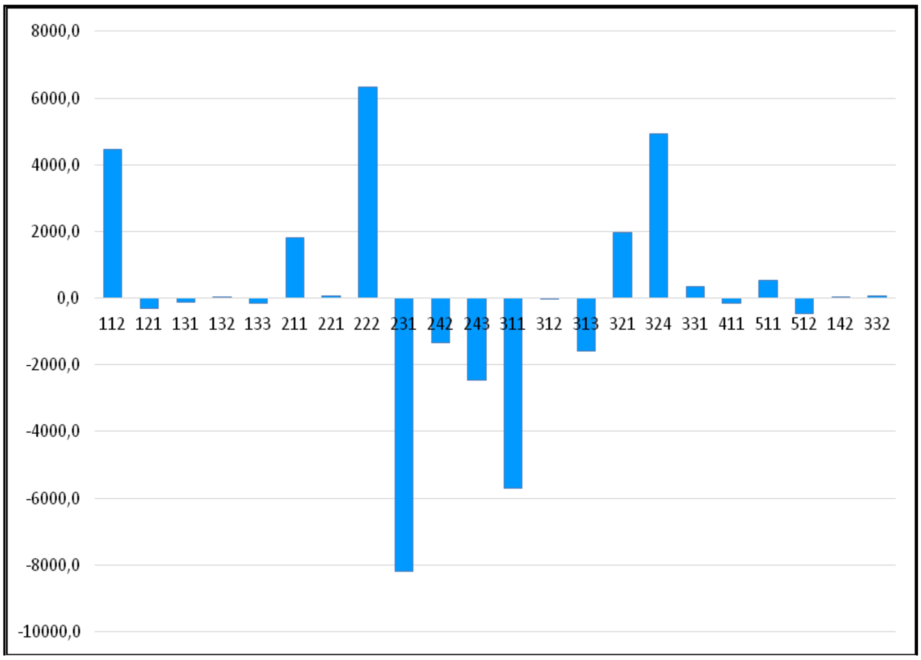

Figure 10. Differences in hectares between CLC 1990 and CLC 2012.

In 2012, unlike 2018 (Fig. 11), notable differences were recorded in classes 222 (fruit tree and shrub plantations) and 242 (complex crop areas).

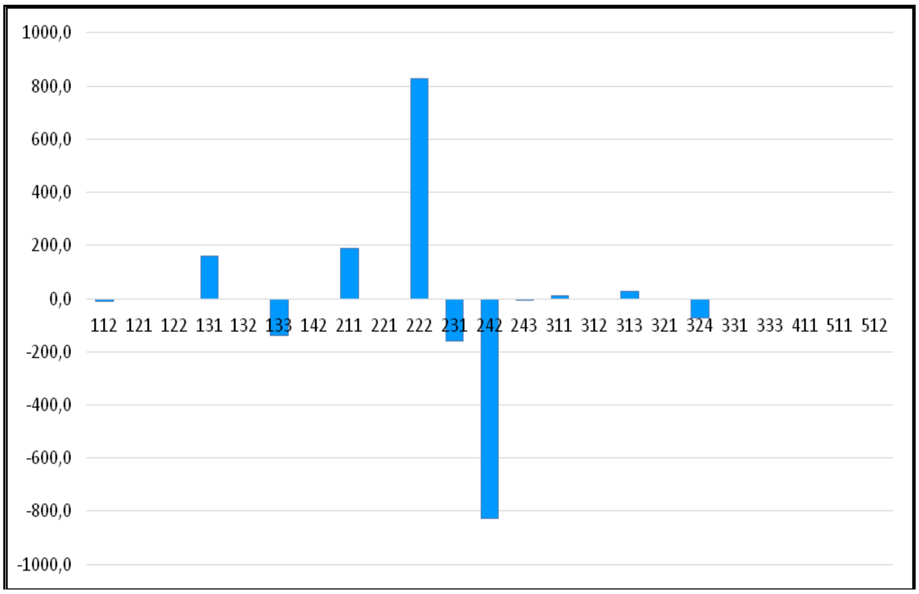

Figure 11. Differences in hectares between CLC 2012 and CLC 2018.

In the differences recorded between 2012 and 2018, the classes with the highest values were 222 (fruit tree and shrub plantations) and 231 (pastures). In 2018, fruit tree and shrub plantations covered 26410.3 ha, unlike in 1990, when they covered 33552.1 hectares.

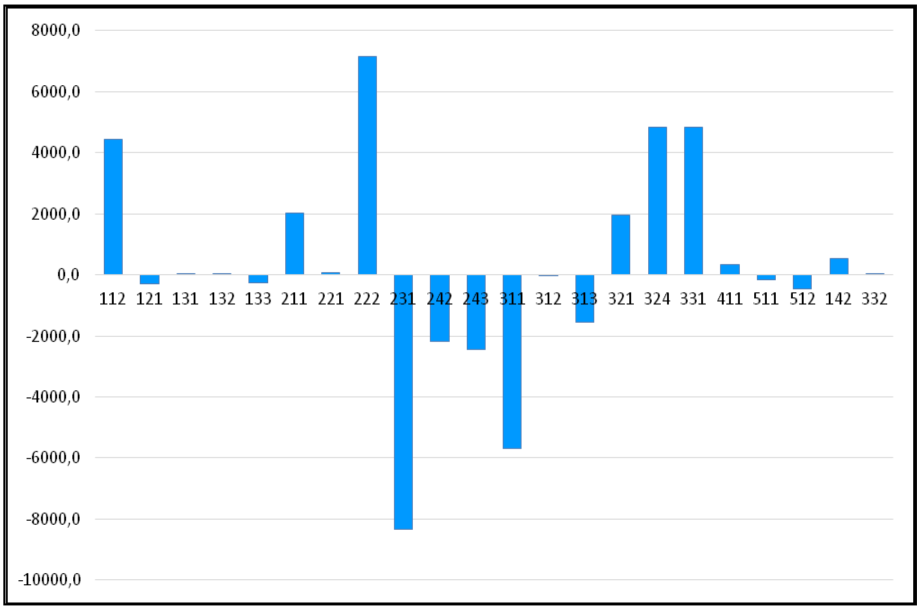

Figure 12. Differences in hectares between CLC 1990 and CLC 2018.

In 1990, unlike in 2018 (Fig. 12), notable differences were recorded in classes 112 (discontinuous urban space), 222 (fruit tree and shrub plantations), 231 (pastures), 311 (deciduous forests), 324 (forest–reed transition), and 331 (beaches, dunes, sands).

We extracted green spaces and land use data for the South-West Oltenia Region from Landsat 5 TM satellite images (26.05.2000–30.08.2000), Landsat 7 ETM+ satellite images (26.05.2012–30.08.2012), Landsat 8 OLI/TIRS satellite images (23.05.2022–28.08.2022) (USGS) and Corine Land Cover (CLC) (Copernicus Monitoring Service) for the years 2000, 2012, and 2018.

To analyze the evolution of green spaces for 2000–2022 (Fig. 13), we generated three vegetation indices (NDVI) for the years 2000, 2012, and 2022, from which we extracted the green surfaces and calculated their area.

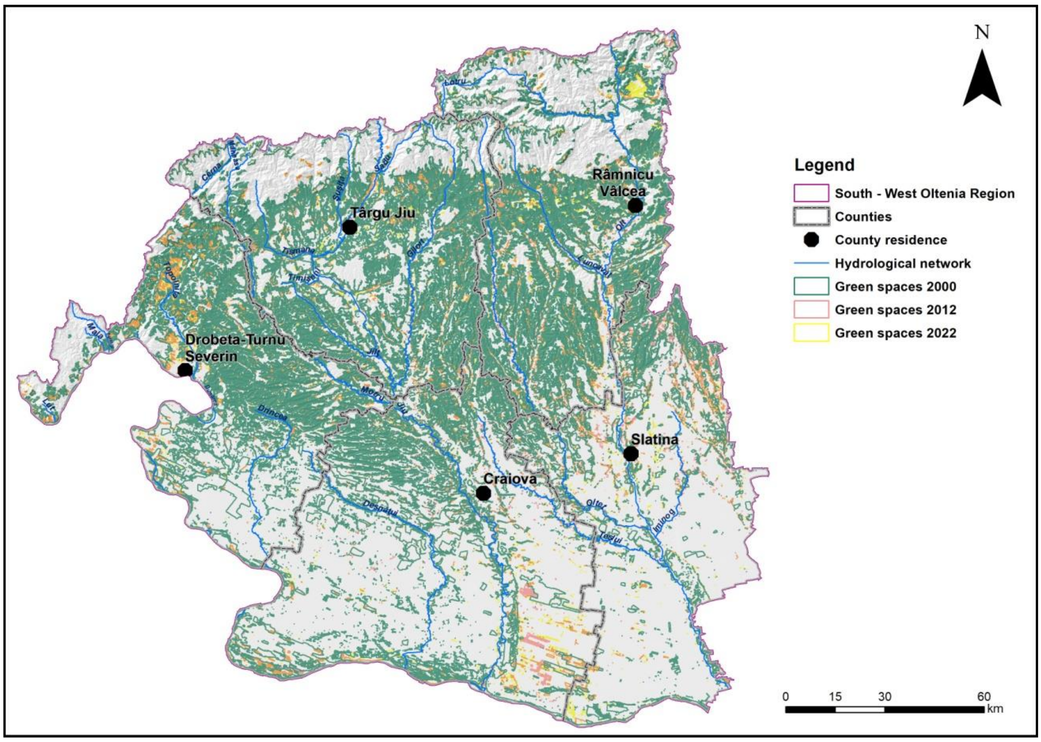

Figure 13. Evolution of green spaces for the period 2000–2022. Source: author-processed https://earthexplorer.usgs.gov/ data, 2024.

Based on the graph in Figure 14, we can conclude that between 2000 and 2022, the area was characterized by a total decrease of 262.26 km^2 in green surfaces. There was a slight increase of 274.88 km^2 between 2000 and 2012, while between 2012 and 2022, the South-West Oltenia Region area was characterized by a decrease of 537.14 km^2.

Green spaces and green infrastructure (TAYLOR & HOCHULI, 2017), through the presence and opportunities offered by urban and peri-urban forests, play a key role in major cities in the Oltenia Region, Romania, and worldwide.

Urban and peri-urban forests can improve environmental quality (MARINESCU & CURCAN, 2020; DRĂGULEASA et al., 2024; CREȚAN et al., 2024), on the one hand, and quality of life through the social function of forests, on the other hand (ADEGUN et al., 2021). Additionally, how urban forests are used, through their protective, productive, or social functions (TOMPROU, 2023; ONCINI et al., 2024), is particularly important and taken into account during sustainable and smart urban planning (ALPAIDZE & SALUKVADZE, 2023).

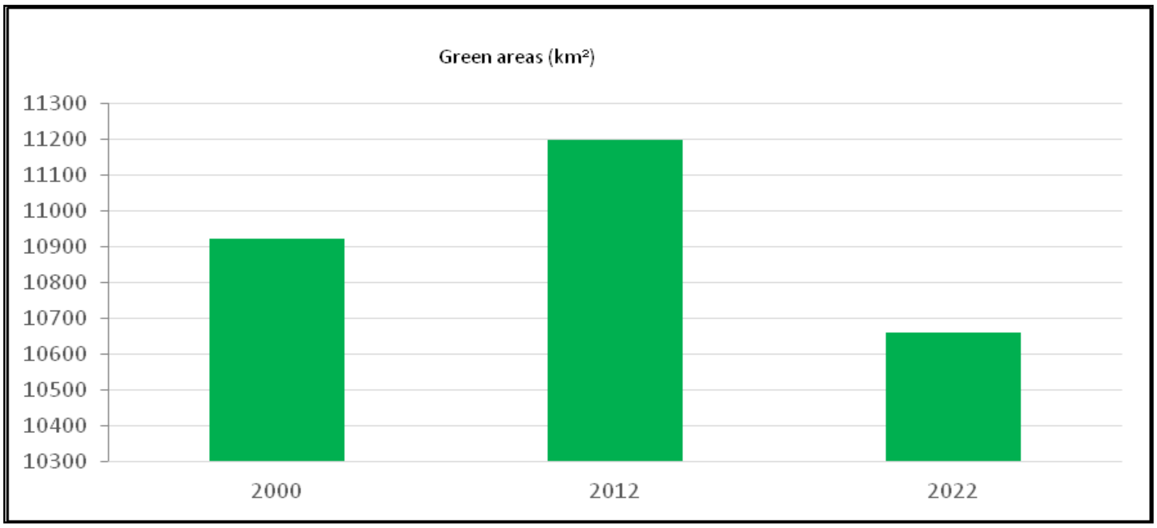

Figure 14. Evolution of green spaces between 2000 and 2022.

To study the correlation between the evolution of land use and green spaces, we extracted land cover data for the years 2000 and 2022 from the Corine Land Cover database and the satellite images mentioned above using a supervised classification method. The changes were analyzed using Change Detection, which detects and calculates each changed pixel (Fig. 15).

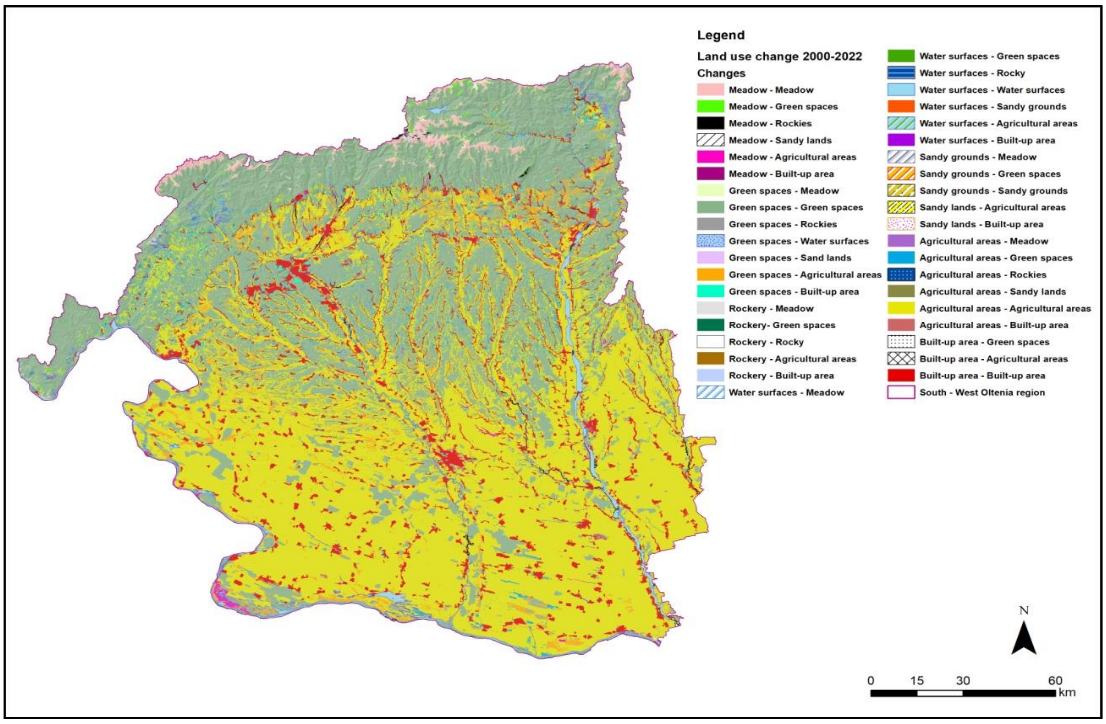

Figure 15. Land use change between 2000 and 2022.
Source: author-processed ***. https://land.copernicus.eu/pan-european/corine-land-cover data, 2024.

Table 2, generated based on the map in Figure 15, shows that the following changes occurred in green spaces between 2000 and 2022: 110.53 km^2 was converted into built-up areas, 1.60 km^2 turned into rock, 43.14 km^2 became grasslands, 0.17 km^2 became sandy lands, 1189.63 km^2 was converted into agricultural lands, and 11.37 km^2 became wetlands, and 9565.94 km^2 remained unchanged.

Table 2. Land use changes between 2000 and 2022.

Change	Area (km^2)
Water surfaces–Built-up area	1.86
Water Surfaces–Rock	0.03
Water Surfaces–Meadow	0.02
Water surfaces–Sandy terrain	1.05
Water surfaces–Agricultural areas	12.96
Water Surfaces–Water Surfaces (unchanged)	577.87
Water surfaces–Green spaces	22.50
Built-up area–Built-up area (unchanged)	1783.29
Built-up area–Agricultural areas	0.00
Built-up area–Green spaces	0.01
Green spaces–Built-up area	110.53
Green spaces–Rock	1.60
Green spaces–Meadow	43.14
Green spaces–Sandy terrain	0.17
Green spaces–Agricultural areas	1189.63
Green spaces–Water surfaces	11.37
Green spaces–Green spaces (unchanged)	9565.94
Agricultural areas–Built-up area	192.53
Agricultural areas–Rock	0.42
Agricultural areas–Meadow	49.58

Agricultural areas–Sandy lands	3.48
Agricultural areas–Agricultural areas (unchanged)	14090.83
Agricultural areas–Green spaces	972.96
Meadow–Built-up area	0.38
Meadow–Rock	14.36
Meadow–Meadow (unchanged)	360.94
Meadow–Sandy terrain	0.00
Meadow–Agricultural areas	61.88
Meadow–Green spaces	91.17
Rock–Built-up area	0.41
Rock–Rock (unchanged)	6.23
Rock–Meadow	6.44
Rock–Agricultural areas	1.40
Rock–Green spaces	1.52
Sandy Land–Built-up Area	2.71
Sandy terrain–Meadow	0.96
Sandy Lands–Sandy Lands (unchanged)	7.85
Sandy lands–Agricultural areas	13.91
Sandy terrain–Green spaces	5.18

We also observe the reverse of the above phenomenon, i.e., 22.50 km^2 of wetlands and surfaces, 0.01 km^2 of built-up areas, 972.96 km^2 of agricultural areas, 5.18 km^2 of sandy lands, 1.52 km^2 of rocky areas, and 91.17 km^2 of meadows were transformed into green spaces.

According to the INS, the total land area in the South-West Oltenia Development Region in 1990 and 2012 was 2921169 hectares. The same is true for all five counties in the region, i.e, the land area in both years was the same for all the counties.

The largest area was Dolj County (741,401 hectares), while the smallest area was Mehedinți County (493,289 hectares) (Fig. 16).

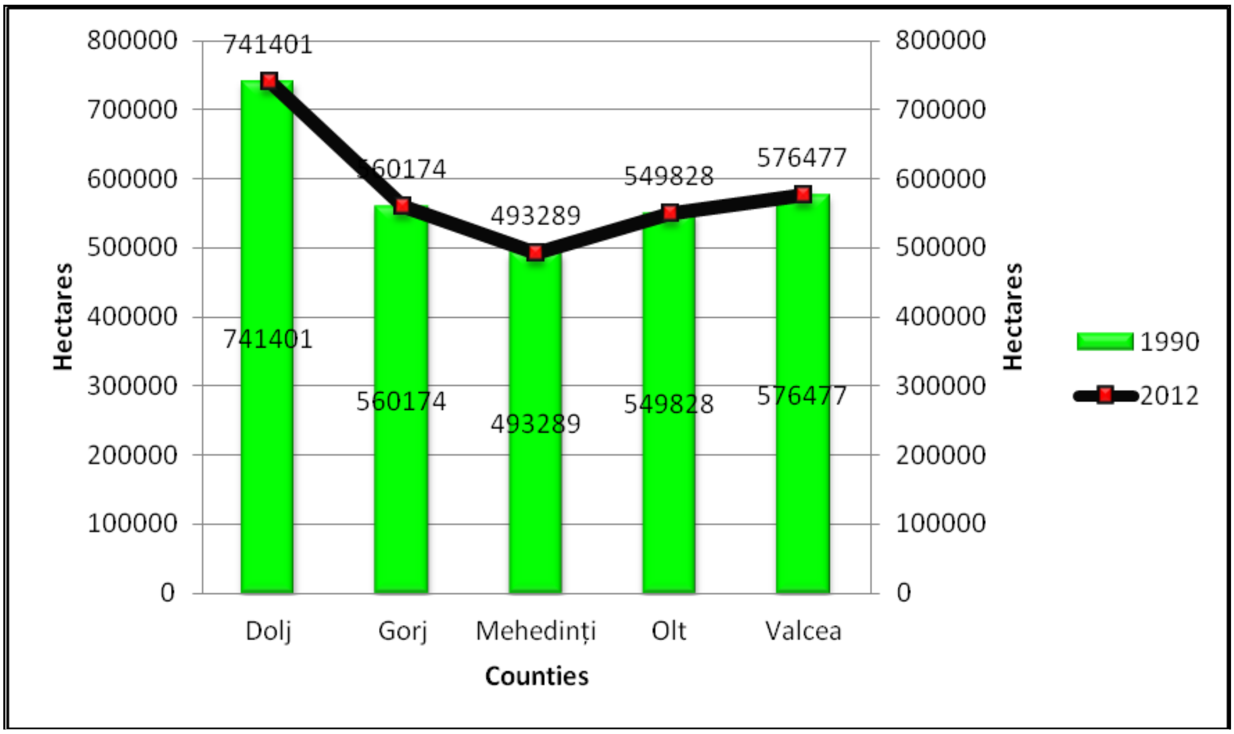

Figure 16. Land area in the counties of the South-West Oltenia Region. Source: author-processed INS data, 2025.

CONCLUSIONS

In conclusion, Geographic Information System (GIS) techniques save time, and the results are visually interactive and offer the possibility of geoprocessing, interpolation, rasterization, and vectorization of statistical data, with the cartographic information being more suggestive and accurate. GIS programs have in common a multitude of diverse functions and procedures for analyzing raster or vector datasets for any relief unit, tourist area, development region, or country.

Using high-resolution satellite images superimposed on processed geodata led to an accurate assessment of land use in the South-West Oltenia Region, Romania. According to TACHE et al. (2023), the use of land ownership data, whether private or state, and the overlay of processed geodata with high-resolution satellite images represents a great methodological advantage in identifying the most accurate land use and change relationships in the Subcarpathians Vâlcii, South-West Oltenia Region, Romania.

Notable differences in land use in the Subcarpathians Vâlcii, Romania, based on CLC classes were recorded between 2012 and 2018 and between 1990 (first year analyzed) and 2018 (last year analyzed). These significant differences are graphically presented in Figs 11 and 12.

Figure 14 shows that there was a total decrease of 262.26 km^2 in green areas in the South-West Oltenia Region, Romania, between 2000 and 2022; additionally, there was a slight increase of 274.88 km^2 between 2000 and 2012, and a decrease of 537.14 km^2 in green areas between 2012 and 2022 in this region.

Future research will use the Normalized Difference Vegetation Index (NDVI), a popular index for measuring spatial changes in vegetated areas (NGUYEN et al., 2022). The NDVI value varies from -1 to 1; the higher the value, the higher the tree density (VIET DU et al., 2023).

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ABBREVIATIONS

NIS National Institute of Statistics
LULC Land use and land cover
SDGs Sustainable Development Goals
RS Remote sensing
GIS Geographical Information System
USA United States of America
CLC Corine Land Cover
NDVI Normalized Difference Vegetation Index

REFERENCES

ABDOU A. H., HASSAN T. H., EL DIEFi M. M. 2020. A Description of Green Hotel Practices and Their Role in Achieving Sustainable Development. *Sustainability*. **12**(22): 9624. https://doi.org/10.3390/su12229624 (accessed December, 2024).

ADAMS R. M., HURD B. H., LENHART S., LEARY N. 1998. Effects of global climate change on agriculture: an interpretative review. *Climate research*. **11**(1): 19-30. https://www.int-res.com/articles/cr/11/c011p019.pdf (accessed December, 2024).

ADEGUN O. B., IKUDAYISI A. E., MORAKINYO T. E., OLUSOGA O. O. 2021. Urban green infrastructure in Nigeria: A review. *Scientific African*. **14**: e01044. https://doi.org/10.1016/j.sciaf.2021.e01044 (accessed December, 2024).

AGOVINO M., CASACCIA M., CIOMMI M., FERRARA M., MARCHESANO K. 2019. Agriculture, climate change and sustainability: The case of EU-28. *Ecological Indicators*. **105**: 525-543. https://doi.org/10.1016/j.ecolind.2018.04.064 (accessed December, 2024).

AHLSTRÖM A., XIA J., ARNETH A., LUO Y., SMITH B. 2015. Importance of vegetation dynamics for future terrestrial carbon cycling. *Environmental Research Letters*. **10**(5): 054019. http://dx.doi.org/10.1088/1748-9326/10/5/054019 (accessed December, 2024).

ALPAIDZEl L. & SALUKVADZE J. 2023. Green in the City: Estimating the Ecosystem Services Provided by Urban and Peri-Urban Forests of Tbilisi Municipality, Georgia. *Forests*. **14**(1): 121. https://doi.org/10.3390/f14010121 (accessed December, 2024).

AMANI M., GHORBANIAN A., AHMADI S. A., KAKOOEI M., MOGHIMI A., MIRMAZLOUMI S. M. 2020. Google earth engine cloud computing platform for remote sensing big data applications: A comprehensive review. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*. **13**: 5326-5350. https://doi.org/10.1109/JSTARS.2020.3021052 (accessed December, 2024).

AMINI S., SABER M., RABIEI-DASTJERDI H., HOMAYOUNI S. 2022. Urban Land Use and Land Cover Change Analysis Using Random Forest Classification of Landsat Time Series. *Remote Sensing*. **14**(11): 2654. https://doi.org/10.3390/rs14112654 (accessed December, 2024).

AOUISSI H. A., PETRIȘOR A.-I., ABABSA M., BOȘTENARU-DAN M., TOURKI M., BOUSLAMA Z. 2021. Influence of Land Use on Avian Diversity in North African Urban Environments. *Land*. **10**(4): 434. https://doi.org/10.3390/land10040434 (accessed December, 2024).

BEER C., REICHSTEIN M., TOMELLERI E., CIAIS P., JUNG M., CARVALHAIS N. 2010. Terrestrial gross carbon dioxide uptake: global distribution and covariation with climate. *Science*. **329**(5993): 834-838. https://doi.org/10.1126/science.1184984 (accessed December, 2024).

BIELECKA E. 2020. GIS Spatial Analysis Modeling for Land Use Change. A Bibliometric Analysis of the Intellectual Base and Trends. *Geosciences*. **10**(11): 421. https://doi.org/10.3390/geosciences10110421 (accessed December, 2024).

CARLSON T. N. & SANCHEZ-AZOFEIFA G. A. 1999. Satellite remote sensing of land use changes in and around San José, Costa Rica. *Remote Sensing of Environment*. **70**(3): 247-256. https://doi.org/10.1016/S0034-4257(99)00018-8 (accessed December, 2024).

CHEVAL S., DUMITRESCU A., ADAMESCU M., CAZACU C. 2020. Identifying climate change hotspots relevant for ecosystems in Romania. *Climate Research*. **80**(3): 165-173. https://doi.org/10.3354/cr01603 (accessed December, 2024).

COCHECI R.-M. & PETRIȘOR A.-I. 2023. Assessing the Negative Effects of Suburbanization: The Urban Sprawl Restrictiveness Index in Romania's Metropolitan Areas. *Land*. **12**(5): 966. https://doi.org/10.3390/land12050966 (accessed December, 2024).

CONSTANTINESCU E., DRĂGULEASA I.-A., MAZILU M., NĂSTASE S. 2023. Development of Eco-sustainable agriculture through a spatio-temporal GIS analysis of agricultural crops. Case study: South-West Oltenia Region. *"Annals of the University of Craiova-Agriculture Montanology Cadastre Series"*. **53**(2): 171-179. https://doi.org/10.52846/aamc.v53i2.1493 (accessed December, 2024).

COWEN D. J. 1988. GIS versus CAD versus DBMS: what are the differences? *Photogrammetric Engineering and Remote Sensing*. **54**(11): 1551-1555. https://www.asprs.org/wp-content/uploads/pers/1988journal/nov/1988_nov_1551-1555.pdf (accessed December, 2024).

CREȚAN R., CHASCIAR D., DRĂGAN A. 2024. Forests and Their Related Ecosystem Services: Visitors' Perceptions in the Urban and Peri-Urban Spaces of Timișoara, Romania. *Forests*. **15**(12): 2177. https://doi.org/10.3390/f15122177 (accessed December, 2024).

CURCAN GH., DRĂGULEASA I.-A., MARINESCU I. E. 2023. Practical model of climate variability and vegetation distribution in the Oltenia Plain. *Oltenia, Studii și Comunicări Seria Științele Naturii*. Muzeul Olteniei Craiova. **39**(1): 272-284.

DRĂGAN A., CREȚAN R., TRIPONESCU A. 2025. Mental maps, generational insights and symbols of urban spaces in a Romanian context. *GeoJournal*. **90**(2): 64. https://doi.org/10.1007/s10708-025-11308-6 (accessed December, 2024).

DRĂGAN A., CREȚAN R., LUNGU M. A. 2024a. Neglected and Peripheral Spaces: Challenges of Socioeconomic Marginalization in a South Carpathian Area. *Land*. **13**(7): 1086. https://doi.org/10.3390/land13071086 (accessed December, 2024).

DRĂGAN A., CREȚAN R., BULZAN R. D. 2024b. The spatial development of peripheralisation: The case of smart city projects in Romania. *Area*. **56**(1): e12902. https://doi.org/10.1111/area.12902 (accessed December, 2024).

DRĂGULEASA I.-A., CURCAN GH., MAZILU MIRELA, CIOBOIU OLIVIA, MARINESCU I. E. 2024. The evolution of urban green spcaces (UGS). Case Study: South-West Oltenia Region. *Oltenia, Studii si Comunicari Seria Stiintele Naturii*, Muzeul Olteniei Craiova. **40**(1): 206-217.

DRĂGULEASA I.-A., NIȚĂ AMALIA, MAZILU MIRELA, CURCAN GH. 2023. Spatio-Temporal Distribution and Trends of Major Agricultural Crops in Romania Using Interactive Geographic Information System Mapping. *Sustainability*. **15**(20): 14793. https://doi.org/10.3390/su152014793 (accessed December, 2024).

DEZSO Z., BARTHOLY J., PONGRACZ R., BARCZA Z. 2005. Analysis of land-use/land-cover change in the Carpathian region based on remote sensing techniques. *Physics and Chemistry of the Earth, Parts A/B/C*. **30**(1-3): 109-115. https://doi.org/10.1016/j.pce.2004.08.017 (accessed December, 2024).

FOLEY J. A., DEFRIES R., ASNER G. P., BARFORD C., BONAN G., CARPENTER S. R. 2005. Global Consequences of Land Use. *Science*. **309**(5734): 570-574. https://doi.org/10.1126/science.1111772 (accessed December, 2024).

GUERSCHMAN J. P., PARUELO J. M., BELLA C. D., GIALLORENZI M. C., PACIN F. 2003. Land cover classification in the Argentine Pampas using multi-temporal Landsat TM data. *International Journal of Remote Sensing*. **24**(17): 3381-3402. https://doi.org/10.1080/0143116021000021288 (accessed December, 2024).

HORODNIC V.-D., GRAUR D. S., AFLOARI M., EFROS V. 2018. May. Geospatial analysis of land use dynamics using historical maps and GIS techniques. Case study of Rădăuți. Romania. In *International Scientific Conference GEOBALCANICA* (pp. 577-597). http://dx.doi.org/10.18509/GBP.2018.63 (accessed December, 2024).

HORODNIC V.-D., BISTRICEAN P.-I., MIHĂILĂ D., EFROS V. 2019a. Assessment of land use changes and landscape fragmentation in the tourism area of Cacica and Vatra Dornei. *GEOREVIEW: Scientific Annals of Ștefan cel Mare University of Suceava. Geography Series*. **29**(1): 12-30. https://georeview.usv.ro/wp-content/uploads/2023/05/Article.2-Vol.29-1.pdf (accessed December, 2024).

HORODNIC V.-D., BISTRICEAN P.-I., MIHĂILĂ D., EFROS V. 2019b. January. Geospatial analysis of landscape dynamics in response to land use and land cover changes in the Suceava river basin (Romania). In *EGU General Assembly Conference Abstracts* (p. 1289). https://presentations.copernicus.org/EGU2019/EGU2019-1289_presentation.pdf (accessed December, 2024).

HOWDEN S. M., SOUSSANA J.-F., TUBIELLO F. N., CHHETRI N., DUNLOP M., MEINKE H. 2007. Adapting agriculture to climate change. *Proceedings of the national academy of sciences*. **104**(50): 19691-19696. https://doi.org/10.1073/pnas.0701890104 (accessed December, 2024).

IELENICZ M., PĂTRU I.G., GHINCEA M. 2003. Subcarpații României, Edit. Universitară. București. 264 pp.

JI Q., LIANG W., FU B., ZHANG W., YAN J., LÜ Y., YUE C., JIN Z., LAN Z., LI S., YANG P. 2021. Mapping Land Use/Cover Dynamics of the Yellow River Basin from 1986 to 2018 Supported by Google Earth Engine. *Remote Sensing*. **13**(7): 1299. https://doi.org/10.3390/rs13071299 (accessed December, 2024).

KALNAY E., & CAI M. 2003. Impact of urbanization and land-use change on climate. *Nature*. **423**(6939): 528-531. https://doi.org/10.1038/nature01675 (accessed December, 2024).

KOSCHKE L., FÜRST C., FRANK S., MAKESCHIN F. 2012. A multi-criteria approach for an integrated land-cover-based assessment of ecosystem services provision to support landscape planning. *Ecological Indicators*. **21**: 54-66. https://doi.org/10.1016/j.ecolind.2011.12.010 (accessed December, 2024).

KUCSICSA G., POPOVICI E.-A., BĂLTEANU D., DUMITRAȘCU M., GRIGORESCU I., MITRICĂ B. 2020. Assessing the potential future forest-cover change in Romania, predicted using a scenario-based modelling. *Environmental Modeling & Assessment*. **25**: 471-491. https://doi.org/10.1007/s10666-019-09686-6 (accessed December, 2024).

LI C., DE JONG R., SCHMID B., WULF H., SCHAEPMAN M. E. 2019. Spatial variation of human influences on grassland biomass on the Qinghai-Tibetan plateau. *Science of the Total Environment*. **665**: 678-689. https://doi.org/10.1016/j.scitotenv.2019.01.321 (accessed December, 2024).

MALHI G. S., KAUR M., KAUSHIK P. 2021. Impact of Climate Change on Agriculture and Its Mitigation Strategies: A Review. *Sustainability*. **13**(3): 1318. https://doi.org/10.3390/su13031318 (accessed December, 2024).

MARINESCU I. E., & CURCAN G. 2020. Recreational quality of urban green spaces. Case Study-Craiova. *Annalls of the University of Craiova. Series Geography/Analele Universitatii din Craiova. Seria Geografie*, **21**: 29-38. https://analegeo.ro/wp-content/uploads/2021/06/3.-Marinescu-Curcan-29-38-bun.pdf (accessed December, 2024).

MIHAI G., ALEXANDRU A.-M., NITA I.-A., BIRSAN M.-V. 2022. Climate Change in the Provenance Regions of Romania over the Last 70 Years: Implications for Forest Management. *Forests*. **13(**8): 1203. https://doi.org/10.3390/f13081203 (accessed December, 2024).

MU K., TANG C., TOSI L., LI Y., ZHENG X., DONNICI S., SUN J., LIU J., GAO X. 2024. Coastline Monitoring and Prediction Based on Long-Term Remote Sensing Data—A Case Study of the Eastern Coast of Laizhou Bay, China. *Remote Sensing*. **16**(1): 185. https://doi.org/10.3390/rs16010185 (accessed December, 2024).

NADAL J., SÁEZ D., MARGALIDA A. 2022. Crossing artificial obstacles during migration: The relative global ecological risks and interdependencies illustrated by the migration of common quail Coturnix coturnix. *Science of the Total Environment*. **808**: 152173. https://doi.org/10.1016/j.scitotenv.2021.152173 (accessed December, 2024).

NATH B., NIU Z., SINGH R. P. 2018. Land Use and Land Cover Changes, and Environment and Risk Evaluation of Dujiangyan City (SW China) Using Remote Sensing and GIS Techniques. *Sustainability*. **10**(12): 4631. https://doi.org/10.3390/su10124631 (accessed December, 2024).

NGUYEN H. D., QUANG-THANH B., NGUYEN Q. H., NGUYEN T. G., PHAM L. T., NGUYEN X. L. 2022. A novel hybrid approach to flood susceptibility assessment based on machine learning and land use change. Case study: a river watershed in Vietnam. *Hydrological Sciences Journal*. **67**(7): 1065-1083. https://doi.org/10.1080/02626667.2022.2060108 (accessed December, 2024).

NOBY M., ELATTAR M. E., HAMDY O. A. 2023. Machine Learning Model to Predict Urban Sprawl Using Official Land-use Data. *Urbanism. Arhitectură. Construcții.* **14**(3): 249-258. https://uac.incd.ro/Art/v14n3a3.pdf (accessed December, 2024).

OLORUNFEMI I. E., FASINMIRIN J. T., OLUFAYO A. A., KOMOLAFE A. A. 2020. GIS and remote sensing-based analysis of the impacts of land use/land cover change (LULCC) on the environmental sustainability of Ekiti State, southwestern Nigeria. *Environment, Development and Sustainability*. **22**: 661-692. https://doi.org/10.1007/s10668-018-0214-z (accessed December, 2024).

ONCINI F., HIRTH S., MYLAN J., ROBINSON C. H., JOHNSON D. 2024. Where the wild things are: How urban foraging and food forests can contribute to sustainable cities in the Global North. *Urban Forestry & Urban Greening*. **93**: 128216. https://doi.org/10.1016/j.ufug.2024.128216 (accessed December, 2024).

PAN Y., BIRDSEY R. A., FANG J., HOUGHTON R., KAUPPI P. E., KURZ W. A. 2011. A large and persistent carbon sink in the world's forests. *Science*. **333**(6045): 988-993. https://doi.org/10.1126/science.1201609 (accessed December, 2024).

PATRICHE C. V. & IRIMIA L. M. 2022. Mapping the impact of recent climate change on viticultural potential in Romania. *Theoretical and Applied Climatology*. **148**(3): 1035-1056. https://doi.org/10.1007/s00704-022-03984-y (accessed December, 2024).

PETRIȘOR A.-I., BRAGUȚA E., ȚUGULEA A., TACHE A.-V., HAREA O., MOGÎLDEA V., POPESCU O.-C., ANDRONOVICI D., BEJAN I. 2025. Using Geospatial Information Tools to Plan Green Infrastructures in Response to Climate Changes: Examples from Bucharest, Romania and Chisinau, Moldova. *Urban Science*. **9**(3): 62. https://doi.org/10.3390/urbansci9030062 (accessed December, 2024).

PETRIȘOR A.-I. & PETRIȘOR L. E. 2021. Recent land cover and use in Romania: A conservation perspective. *Present Environment and Sustainable Development.* **15**(1): 81-92. http://dx.doi.org/10.15551/pesd2021151007 (accessed December, 2024).

PETRIȘOR A.-I., SIRODOEV I., IANOȘ I. 2020a. Trends in the National and Regional Transitional Dynamics of Land Cover and Use Changes in Romania. *Remote Sensing*. **12**(2): 230. https://doi.org/10.3390/rs12020230 (accessed December, 2024).

PETRIȘOR A.-I., HAMMA W., NGUYEN H. D., RANDAZZO G., MUZIRAFUTI A., STAN M.-I., TRAN V. T., AȘTEFĂNOAIEI R., BUI Q.-T., VINTILĂ D.-F., TRUONG Q. H., LIXĂNDROIU C., ȚENEA D.-D., SÎRODOEV I., IANOȘ I. 2020b. Degradation of Coastlines under the Pressure of Urbanization and Tourism: Evidence on the Change of Land Systems from Europe, Asia and Africa. *Land*. **9**(8): 275. https://doi.org/10.3390/land9080275 (accessed December, 2024).

PETRIȘOR A.-I. & PETRIȘOR L. E. 2018. Transitional dynamics based trend analysis of land cover and use changes in Romania during 1990-2012. *Present Environment and Sustainable Development*. **12**(2): 215-231. http://dx.doi.org/10.2478/pesd-2018-0042 (accessed December, 2024).

PETRIȘOR A.-I., GRIGOROVSCHI M., MEIȚĂ V., SIMION-MELINTE C.-P. 2014. Long-term environmental changes analysis using corine data. *Environmental Engineering & Management Journal (EEMJ)*. **13**(4): 847-860. http://dx.doi.org/10.30638/eemj.2014.089 (accessed December, 2024).

PETRIȘOR A.-I. 2012. Land cover and land use analysis of urban growth in Romania. *Human Geographies*. **6**(1): 47-51. http://dx.doi.org/10.5719/hgeo.2012.61.47 (accessed December, 2024).

PETRIȘOR A. I., IANOȘ I., TĂLÂNGĂ C. 2010. Land cover and use changes focused on the urbanization processes in Romania. *Environmental Engineering & Management Journal (EEMJ)*. **9**(6): 765-771. http://dx.doi.org/10.30638/eemj.2010.102 (accessed December, 2024).

PHAN T. N., KUCH V., LEHNERT L. W. 2020. Land Cover Classification using Google Earth Engine and Random Forest Classifier—The Role of Image Composition. *Remote Sensing*. ***12***(15): 2411. https://doi.org/10.3390/rs12152411 (accessed December, 2024).

POPESCU O.-C., TACHE A.-V., PETRIȘOR A.-I. 2022. Methodology for Identifying Ecological Corridors: A Spatial Planning Perspective. *Land*. **11**(7): 1013. https://doi.org/10.3390/land11071013 (accessed December, 2024).

POPOVICI E.-A., KUCSICSA G., BĂLTEANU D., GRIGORESCU I., MITRICĂ B., DUMITRAȘCU M., DAMIAN N. 2018. Past and future land use/cover flows related to agricultural lands in Romania. An assessment using CLUE-S Model and CORINE Land Cover Database. *Carpathian Journal of Earth and Environmental Sciences*. **13**(2): 613-628. https://doi.org/10.26471/cjees/2018/013/052 (accessed December, 2024).

PRĂVĂLIE R., SÎRODOEV I., NITA I.-A., PATRICHE C., DUMITRAȘCU M., ROȘCA B. 2022. NDVI-based ecological dynamics of forest vegetation and its relationship to climate change in Romania during 1987–2018. *Ecological Indicators*. **136**: 108629. https://doi.org/10.1016/j.ecolind.2022.108629 (accessed December, 2024).

PRĂVĂLIE R., PEPTENATU D., SIRODOEV I. 2013. The impact of climate change on the dynamics of agricultural systems in south-western Romania. *Carpathian Journal of Earth and Environmental Sciences*. **8**(3): 175-186. https://www.researchgate.net/profile/IgorSirodoev/publication/285892067_The_impact_of_climate_change_on_the_dynamics_of_agricultural_systems_in_South-Western_Romania/links/56d5461b08aed6a7b27626da/The-impact-of-climate-change-on-the-dynamics-of-agricultural-systems-in-South-Western-Romania.pdf (accessed December, 2024).

REICHSTEIN M., BAHN M., CIAIS P., FRANK D., MAHECHA M. D., SENEVIRATNE S. I. 2013. Climate extremes and the carbon cycle. *Nature*. **500**(7462): 287-295. https://doi.org/10.1038/nature12350 (accessed December, 2024).

REIS S. 2008. Analyzing Land Use/Land Cover Changes Using Remote Sensing and GIS in Rize, North-East Turkey. *Sensors*. **8**(10): 6188-6202. https://doi.org/10.3390/s8106188 (accessed December, 2024).

ROANGHEȘ-MUREANU A.-M. 2012. Turismul balnear și climateric. Subcarpații Vâlcii, Edit. Universității din București. 296 pp.

ROGAN J. & CHEN D. 2004. Remote sensing technology for mapping and monitoring land-cover and land-use change. *Progress in planning*. **61**(4): 301-325. https://doi.org/10.1016/S0305-9006(03)00066-7 (accessed December, 2024).

ROȘU Al. 1980. Geografia fizică a României. Edit. Didactică și Pedagogică. București. 440 pp.

ROTARU M.-A., CREȚAN R., JUCU I. S., IANĂȘ A.-N., TÖRÖK-OANCE M. 2024. How Can Digital Maps of Religions Inform Us about Fractionalization and Polarization in Post-Communist Romania? *Religions*. **15**(7): 763. https://doi.org/10.3390/rel15070763 (accessed December, 2024).

RUSU T. & MORARU P. I. 2015. Impact of climate change on crop land and technological recommendations for the main crops in Transylvanian Plain, Romania. *Romanian Agricultural Research*. **32**: 103-111. https://new.incda-fundulea.ro/images/rar/nr32/rar3213.pdf (accessed December, 2024).

RUSU T., MORARU P., COSTE C., CACOVEAN H., CHETAN F., CHETAN C. 2014. Impact of climate change on climatic indicators in Transylvanian Plain, Romania. *Journal of Food, Agriculture & Environment*. **12**(1): 469-473.

SALAZAR A., BALDI G., HIROTA M., SYKTUS J., MCALPINE C. 2015. Land use and land cover change impacts on the regional climate of non-Amazonian South America: A review. *Global and Planetary Change*. **128**: 103-119. https://doi.org/10.1016/j.gloplacha.2015.02.009 (accessed December, 2024).

SANDU A. & GROZA O. 2017. What pattern(s) for the urbal sprawl of the post-socialist Romanian cities? *Informatics Geoinformatics Remote Sensing,* In *17th International Multidisciplinary Scientific GeoConference SGEM 2017 Jun 2017*. SGEM2017 Press. Albena. **17**(23): 867-874. https://shs.hal.science/halshs-01561509v1/document (accessed December, 2024).

SĂVAN G., PĂCURAR I., ROȘCA S., MEGYES H., FODOREAN I., BILAȘCO Ș., NEGRUȘIER C., BARA L. V., FILIPOV F. 2024. GIS-Based Agricultural Land Use Favorability Assessment in the Context of Climate Change: A Case Study of the Apuseni Mountains. *Applied Sciences*. **14**(18): 8348. https://doi.org/10.3390/app14188348 (accessed December, 2024).

SLEETER B. M., SOHL T. L., LOVELAND T. R., AUCH R. F., ACEVEDO W., DRUMMOND M. A., SAYLER K. L., STEHMAN S. V. 2013. Land-cover change in the conterminous United States from 1973 to 2000. *Global Environmental Change*. **23**(4): 733-748. https://doi.org/10.1016/j.gloenvcha.2013.03.006 (accessed December, 2024).

SLEETER B. M., LIU J., DANIEL C., RAYFIELD B., SHERBA J., HAWBAKER T. J., ZHU Z., SELMANTS P. C., LOVELAND T. R. 2018. Effects of contemporary land-use and land-cover change on the carbon balance of terrestrial ecosystems in the United States. *Environmental Research Letters*. **13**(4): 045006. https://doi.org/10.1088/1748-9326/aab540 (accessed December, 2024).

SMERALDO S., BOSSO L., FRAISSINET M., BORDIGNON L., BRUNELLI M., ANCILLOTTO L., RUSSO D. 2020. Modelling risks posed by wind turbines and power lines to soaring birds: The black stork (*Ciconia nigra*) in Italy as a case study. *Biodiversity and Conservation*. **29**: 1959-1976. https://doi.org/10.1007/s10531-020-01961-3 (accessed December, 2024).

STERLING S. M., DUCHARNE A., POLCHER J. 2013. The impact of global land-cover change on the terrestrial water cycle. *Nature Climate Change*. **3**(4): 385-390. https://doi.org/10.1038/nclimate1690 (accessed December, 2024).

STRINGER L. C., SCRIECIU S. S., REED M. S. 2009. Biodiversity, land degradation, and climate change: Participatory planning in Romania. *Applied Geography*. **29**(1): 77-90. https://doi.org/10.1016/j.apgeog.2008.07.008 (accessed December, 2024).

TACHE A.-V., POPESCU O.-C., PETRIȘOR A.-I. 2024. Planning Blue–Green Infrastructure for Facing Climate Change: The Case Study of Bucharest and Its Metropolitan Area. *Urban Science*. **8**(4): 250. https://doi.org/10.3390/urbansci8040250 (accessed December, 2024).

TACHE A.-V., POPESCU O.-C., PETRIȘOR A.-I. 2023. Conceptual Model for Integrating the Green-Blue Infrastructure in Planning Using Geospatial Tools: Case Study of Bucharest, Romania Metropolitan Area. *Land*. **12**(7): 1432. https://doi.org/10.3390/land12071432 (accessed December, 2024).

TAYLOR L. & HOCHULI D. F. 2017. Defining greenspace: Multiple uses across multiple disciplines. *Landscape and Urban Planning*. **158**: 25-38. https://doi.org/10.1016/j.landurbplan.2016.09.024 (accessed December, 2024).

TOMPROU M. O. 2023. Opportunities and Challenges for the Creation and Governance of Productive Landscapes in Urban Transformations: The Case of Klosterøya Urban Fruit Forest Park. *Sustainability*. **15**(4): 2864. https://doi.org/10.3390/su15042864 (accessed December, 2024).

TRIPONESCU A., DRAGAN A., CREȚAN R. 2024. Mapping Perception: Analyzing Mental Representations of Urban Space in Timișoara, Romania. *Urban Science*. **8**(4): 205. https://doi.org/10.3390/urbansci8040205 (accessed December, 2024).

ULBRICHT K. A. & HECKENDORFF W. D. 1998. Satellite images for recognition of landscape and landuse changes. *ISPRS Journal of Photogrammetry and Remote Sensing*. **53**(4): 235-243. https://doi.org/10.1016/S0924-2716(98)00006-9 (accessed December, 2024).

VIET DU Q. V., NGUYEN H. D., PHAM V. T., NGUYEN C. H., NGUYEN Q. H., BUI Q. T. 2023. Deep learning to assess the effects of land use/land cover and climate change on landslide susceptibility in the Tra Khuc river basin of Vietnam. *Geocarto International*. **38**(1): 2172218. https://doi.org/10.1080/10106049.2023.2172218 (accessed December, 2024).

WANG S. W., GEBRU B. M., LAMCHIN M., KAYASTHA R. B., LEE W.-K. 2020. Land Use and Land Cover Change Detection and Prediction in the Kathmandu District of Nepal Using Remote Sensing and GIS. *Sustainability*. **12**(9): 3925. https://doi.org/10.3390/su12093925 (accessed December, 2024).

WIATKOWSKA B., SŁODCZYK J., STOKOWSKA A. 2021. Spatial-Temporal Land Use and Land Cover Changes in Urban Areas Using Remote Sensing Images and GIS Analysis: The Case Study of Opole, Poland. *Geosciences*. **11**(8): 312. https://doi.org/10.3390/geosciences11080312 (accessed December, 2024).

WU Q., LI H. Q., WANG R. S., PAULUSSEN J., HE Y., WANG M., WANG Bi. H., WANG Z. 2006. Monitoring and predicting land use change in Beijing using remote sensing and GIS. *Landscape and Urban Planning*. **78**(4): 322-333. https://doi.org/10.1016/j.landurbplan.2005.10.002 (accessed December, 2024).

YAHAYA I., XU R., ZHOU J., JIANG S., SU B., HUANG J., CHENG J., DONG Z., JIANG T. 2024. Projected patterns of land uses in Africa under a warming climate. *Scientific Reports*. **14**(1): 12315. https://doi.org/10.1038/s41598-024-61035-0 (accessed December, 2024).

ZHANG X., LIU L., WU C., CHEN X., GAO Y., XIE S., ZHANG B. 2020. Development of a global 30 m impervious surface map using multisource and multitemporal remote sensing datasets with the Google Earth Engine platform. *Earth System Science Data*. **12**(3): 1625-1648. https://doi.org/10.5194/essd-12-1625-2020 (accessed December, 2024).

ZHU X., WANG Z., GU T., ZHANG Y. 2024. Multi–Scenario Prediction of Land Cover Changes and Habitat Quality Based on the FLUS–InVEST Model in Beijing. *Land*. **13**(8): 1163. https://doi.org/10.3390/land13081163 (accessed December, 2024).

ZORAN M. A., ZORAN L. F. V., DIDA A. I. 2016, October. Forest vegetation dynamics and its response to climate changes. In *Remote Sensing for Agriculture, Ecosystems, and Hydrology XVIII*. SPIE Press. 9998: 598-608. https://doi.org/10.1117/12.2241374 (accessed December, 2024).

***. National Institute of Statistics, TEMPO online: http://statistici.insse.ro:8077/tempo-online/#/pages/tables/insse-table (accessed January, 2025).

***. United Nations. Take Action for the Sustainable Development Goals. Available online: https://www.un.org/sustainabledevelopment/sustainable-development-goals/ (accessed December, 2024).

***. https://geo-spatial.org/vechi/blog/aster-gdem-versiunea-2 (accessed December, 2024).

***. https://land.copernicus.eu/pan-european/corine-land-cover (accessed December, 2024).

***. https://earthexplorer.usgs.gov/ (accessed December, 2024).

Drăguleasa Ionuț-Adrian
University of Craiova, Doctoral School of Science, Faculty of Sciences, Geography Department,
Str. A. I. Cuza 1, 200585, Craiova, Dolj, Romania.
E-mail: draguleasa.ionut.t7h@student.ucv.ro (corresponding author)

Cioboiu Olivia
The Oltenia Museum, Craiova, Str. Popa Șapcă, No. 8, 200422, Craiova, Romania.
E-mails: oliviacioboiu@gmail.com; cioboiu.olivia@yahoo.com

Măceșeanu Daniela Mihaela
The Oltenia Museum, Craiova, Str. Popa Șapcă, No. 8, 200422, Craiova, Romania.
E-mail: daniela.maceseanu@yahoo.com

Alexandru Anca Florentina
The Oltenia Museum, Craiova, Str. Popa Șapcă, No. 8, 200422, Craiova, Romania.
E-mail: petcusinanca@gmail.com

Zaharia Alexandra Lucia
University of Craiova, Faculty of Sciences, Geography Department,
Str. A. I. Cuza 1, 200585, Craiova, Dolj, Romania.
E-mail: alexandra.zaharia@edu.ucv.ro

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