

The Pressure of Urban Sprawl on Agricultural Land in the Emerging System of Bucharest Municipality

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Abstract. *The development of Romania's main economic centres has led to the territorial expansion of urban areas. Analysing land use transformation is very important in understanding the mechanisms that generate such systemic changes. The Corine Land Cover database, provided by Copernicus Land Monitoring Services (CLMS), from 1990-2018, was processed using the open-source software package QGIS, a process that started with the reprojection of the data into the national coordinate reference system Pulkovo 1942(58)/Stereo 70, EPSG: 3844. The methodology used was able to highlight the transformations that have occurred in land use. Our results show that the quantitative and land use changes due to socio-economic pressures caused by the transition to a different type of economy can be highlighted. Urban sprawl has led to significant changes in agricultural land use, with land being used mainly for residential, industrial or transport infrastructure development.*

Keywords: territorial management, land use, agricultural land

Introduction

Urban sprawl puts significant pressure on agricultural land, leading to its conversion for urban development. This phenomenon has been observed on a global scale, giving rise to a variety of socio-economic and environmental impacts. The aim of the research is to spatially model the impact of urban sprawl on other land use categories. Similarly, we highlighted the trends of land use evolution in the Bucharest-Ilfov Development Region.

Urban sprawl, defined as the expansion of urban areas into rural regions, is a global phenomenon that has significant environmental and economic consequences. Studies conducted in Pakistan, Kenya, Egypt and Malaysia have demonstrated that this process leads to a substantial reduction in agricultural land, resulting in the conversion of fertile agricultural land into urban uses.

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This, in turn, has a detrimental effect on agricultural productivity and potential food security issues (Younu & Chaudhry, 2024; Maina & Waiganjo, 2024).

The process whereby urban areas expand into agricultural regions frequently gives rise to changes in the demographic composition of the affected areas. This is due to younger populations migrating to urban areas in pursuit of better opportunities, resulting in an aging farming population. This phenomenon can potentially engender labor shortages and economic instability in rural communities. Urban sprawl has been demonstrated to increase land values, thus rendering it economically attractive to farmers seeking to sell their land. This phenomenon consequently leads to the fragmentation of agricultural land, which in turn further reduces its viability for farming purposes (Younu & Chaudhry, 2024).

The transformation of agricultural terrain into urban space has been demonstrated to occasion ecological concerns including, but not limited to, deforestation, loss of wetlands, and elevated land surface temperatures. These developments have the potential to further compromise both agricultural productivity and environmental wellbeing (Van Berkum, 2023; Maina & Waiganjo, 2024).

In response to the phenomenon of urban sprawl, those engaged in agricultural activities may be compelled to adopt novel strategies. Such strategies may include, but are not limited to, agricultural intensification, diversification, or the cultivation of high-value crops. However, it is important to note that these changes can also result in an increased socioeconomic vulnerability, particularly among individuals who possess weak land rights (Van Berkum, 2023).

The growth-based approach is associated with inadequate planning in newly developed areas. It frequently cites consequences such as pollution and associated health and environmental concerns, tourist dissatisfaction caused by unattractiveness, and economic impact. Inefficiency is also highlighted, with issues including car-dependent city designs with inadequate public transport. Among the driving factors of urban sprawl are economic and population growth, which are rampant and uncontrolled.

It is imperative that sustainable urban planning is implemented in order to achieve a balance between urban growth and the preservation of agricultural land. The development of effective policies is essential for the management of land use changes and the protection of agricultural resources (Udaykumar et al., 2024; Younu & Chaudhry, 2024).

Literature review

Urban sprawl is a phenomenon that has been observed to lead to the conversion of agricultural lands and natural habitats into urban areas. This phenomenon is evident in regions such as Barcelona, where urban expansion has primarily affected agricultural zones (Paül & Tonts, 2005). A similar situation has been observed in New Jersey, where urban sprawl has resulted in the loss of prime farmland, wetlands, and forest habitats (Hasse & Lathrop, 2003).

Urban sprawl is a term used to describe the expansion of cities which is both dispersed and inefficient, resulting in increased impervious surfaces and fragmented urban expansion (Shen et al., 2019). In Taiwan, this phenomenon has been attributed to politically motivated land use decisions, which have resulted in inefficient spatial patterns (Chou & Chang, 2008).

A considerable number of regions encounter difficulties in implementing effective land use plans to control urban expansion. For instance, in China, land use plans have been unsuccessful in managing urban expansion, resulting in fragmented development and the conversion of farmland (Liu et al., 2020).

In the context of Latin America, urban sprawl is influenced by socioeconomic disparities and political agendas, resulting in a variety of land uses and challenges in integrating infrastructural lands into urban planning (Silva, 2017). In Taiwan, economic growth and political decisions have been identified as exacerbating factors contributing to urban sprawl (Chou & Chang, 2008).

The effectiveness of land use planning is subject to variation across different geographical regions. The Netherlands has demonstrated a degree of success in adapting its planning practices to control urban sprawl; in contrast, Belgium and Poland have encountered difficulties in implementing new initiatives in this regard (Halleux, 2012). Comparative studies underscore the necessity for integrated and responsive planning systems in order to mitigate urban sprawl (Bovet et al., 2017).

Agriculture constitutes a pivotal economic sector within the European Union (Morkunas et al., 2018) with a clearly defined objective of ensuring food security for the nation and employment in rural areas, whilst concurrently maintaining and protecting the natural ecological environment (Burja et al., 2020).

The expansion of urban areas has profound and long-term ramifications for agricultural land, particularly in regions experiencing accelerated urbanisation. This expansion often results in the transformation of arable land into urban zones, thereby creating challenges related to food security and the promotion of sustainable growth.

The key impacts of urban expansion on agricultural land are manifold. These include, but are not limited to, the loss of productive croplands, decreased agricultural productivity, socioeconomic and environmental challenges, and regional variations.

Therefore, it is projected that urban expansion will result in a 1.8-2.4% loss of global croplands by 2030, with Asia and Africa experiencing the most significant declines. These regions will lose croplands with a yield that exceeds the national mean by more than twofold, thereby posing a threat to the future resilience of food systems and livelihoods (Chen et al., 2020). The conversion of agricultural land into urban areas has resulted in a decline in net primary productivity, which is comparable to the annual food requirements of millions of people. This phenomenon is particularly salient in developing countries such as China, Vietnam and Egypt, where food security is already a concern (Huang et al., 2020). Urban expansion has been demonstrated to increase competition for land, thus resulting in socioeconomic vulnerabilities, most notably for individuals who possess inadequate land ownership rights. Furthermore, this phenomenon has been shown to precipitate ecological issues, including deforestation and the extinction of wetlands (Van Berkum, 2023). Also, in regions such as the Tarai in Nepal and Larkana in Pakistan, there has been an urban expansion at the expense of agricultural lands, resulting in substantial land-use changes and elevated surface temperatures (Rimal et al., 2020). Should current trends persist, a substantial area of agricultural land in the U.S. and other regions is at risk of being lost to urban development by 2040, with consequential impacts on food production and rural livelihoods (Xie et al., 2023).

Urbanisation is a major threat to agricultural lands, particularly in areas undergoing rapid urbanization. This trend has several consequences, including the loss of highly productive croplands, decreased agricultural productivity, and increased socioeconomic and environmental challenges. In order to mitigate these impacts and ensure sustainable development, effective governance and urban planning are crucial.

Methodology

The present article sought to furnish an alternative perspective on the phenomenon of urban sprawl, thereby contributing to a more nuanced comprehension of the temporal dynamics underlying land use changes.

Study area

The research area selected for investigation is the Bucharest-Ilfov region. Geographically, the region is a lowland area (with an altitude of 50-70 m), characterised by a temperate continental climate and diverse land use (residential, agricultural, industrial, forestry, lakes and transport networks) (Figure 1). The region represents the most significant human, political and industrial agglomeration in Romania. The total number of cities, towns and villages in the region is eight, 32 and 91, respectively. The region's population was recorded as 2,633,690 inhabitants in July 2021, with an area of 1,804 km².

The Bucharest-Ilfov region has the distinction of being the most developed region in Romania. It has a GDP per capita (expressed in standard purchasing power) of 190% of the European average, thus outperforming other regions, including other European capitals such as Athens, Madrid, Rome, Vienna, Berlin or Budapest (cf. Eurostat 2025, based on 2023 data).

The Regional Operational Program for the Bucharest-Ilfov region (2021-2027) is allocated approximately 586.6 million euros from EU funds, with a further 880 million euros allocated from national cofinancing. The EU funds are earmarked for various purposes, including the digitisation of the region, the promotion of dynamic enterprises, the enhancement of regional infrastructure, and the implementation of other strategies to boost territorial growth.



Figure 1. Location of the research region Bucharest - Ilfov

Data source: <https://www.naturalearthdata.com/>

Data and spatial analysis

The present study is based on data from the Corine Land Cover database, provided by Copernicus Land Monitoring Services (CLMS) and available at <https://land.copernicus.eu/en/products/corine-land-cover>. For the years 1990, 2000, 2006, 2012 and 2018, vector datasets in *.gpkg* format were utilised. The data processing and analysis were performed using the open-source software package QGIS, with the data initially being reprojected into the national coordinate reference system Pulkovo 1942(58)/Stereo 70, EPSG: 3844. For each year, the study area was clipped using the Clip

tool in the QGIS Processing toolbox. The Sankey diagram was constructed using a combination of JupyterLab, Python, Pandas and Plotly. The data provided by the Copernicus Land Monitoring Services were extracted in *.x/xs* format using JupyterLab in a Python environment with Pandas.

Following the clipping of the designated study area, the data containing the use codes and the area in hectares for the areas marked with these codes were exported in *.xlsx* format. These data were then processed and analysed to generate the area evolution graph, represented by the Sankey diagram. This diagram is a particularly pertinent cartographic representation of the processes, illustrating the structural changes for each period for which data is available.

Results and discussions

The findings of research conducted to date demonstrate that the accelerated expansion of urban areas, resulting from uncontrolled residential development, is exerting considerable pressure on arable land. This phenomenon, it is demonstrated, has significant implications for land use, the environment, and economic development (Hirpa et al., 2023; Abdeljawad & Nagy, 2023).

Further analysis is required to ascertain the causal relationships between urban expansion and land use change. The present study validates the assertion that urban sprawl leads to a reduction in the area of agricultural land; however, further exploration is required to ascertain the causal mechanisms driving these transformations. Determinants such as high housing demand, speculation in the real estate market, or infrastructure modernisation and expansion are key drivers of land use dynamics. A comparative approach with other urban contexts could provide additional data and a deeper understanding of these mechanisms.

From a methodological perspective, our research employs Geographic Information System (GIS) and flow visualization techniques, in conjunction with the transformation of land categories over time (Sankey diagram), to provide an integrated perspective on land use dynamics. This perspective is further confirmed, in conjunction with other studies, of the usefulness of these methodologies as complementary tools that improve the understanding of the impact of urban sprawl on land use (Peptenatu et al., 2020).

The year 1990 is of particular significance in the context of Romanian society and economy, marking a major turning point in the transition from a socialist-type economy to a capitalist-type economy. This shift is characterised by a transition from centralised, planned economic direction by the country's political leadership to a more market-driven approach. The process of transformation is complex and multifaceted, involving several stages of economic and political adjustment.

The aforementioned changes are also reflected in the land use and transformation of emerging areas in major cities. A reduction in arable area was observed over the entire period analysed, with the area that had changed its functionality being the main category affected by urban sprawl (Table 1). It is noteworthy that at the conclusion of the analysed period, a significant percentage of irrigated arable land adopted a different functionality, while vineyards and orchards experienced a reduction in cultivated areas by more than 65%.

Table 1. Land use matrix in the emerging territorial system Bucharest

CODE	DESCRIPTION	1990 (ha)	2000 (ha)	% 2000/1990	2006 (ha)	% 2006/2000	2012 (ha)	% 2012/2006	2018 (ha)	% 2018/2012
111	Continuous urban fabric	1308,9	1308,9	0,0	7847,5	499,5	10092,8	28,6	10169,5	0,8
112	Discontinuous urban fabric	24209,5	24699,2	2,0	20926,0	-15,3	16821,0	-19,6	17624,6	4,8
121	Industrial or commercial units	5107,4	5281,9	3,4	8056,5	52,5	8197,8	1,8	8587,7	4,8
122	Road and rail networks and associated land	503,4	503,4	0,0	270,2	-46,3	465,3	72,2	465,3	0,0
131	Mineral extraction sites	0,0	0,0	0,0	52,7	0,0	413,3	684,3	444,3	7,5
132	Dump sites	47,0	47,0	0,0	111,5	137,2	267,6	140,0	277,9	3,8
133	Construction sites	34,1	66,7	95,6	828,3	1141,8	5265,4	535,7	5715,2	8,5
141	Green urban areas	1344,8	1344,8	0,0	1285,2	-4,4	1228,8	-4,4	1268,5	3,2
211	Non-irrigated arable land	101586,4	100933,1	-0,6	95261,1	-5,6	79672,6	-16,4	80611,9	1,2
221	Vineyards	455,0	413,3	-9,2	220,8	-46,6	726,9	229,2	590,9	-18,7
222	Fruit trees and berry plantations	2136,9	2125,2	-0,5	2081,5	-2,1	10667,0	412,5	8296,3	-22,2
231	Pastures	2847,2	2818,8	-1,0	3410,3	21,0	11193,8	228,2	11004,9	-1,7
242	Complex cultivation patterns	5524,1	5575,9	0,9	4700,2	-15,7	991,7	-78,9	977,6	-1,4
243	Land principally occupied by agriculture, with significant areas of natural vegetation	1522,3	1523,1	0,1	1069,1	-29,8	24195,4	2163,2	23868,9	-1,3
311	Broad-leaved forest	26201,2	26200,2	0,0	25719,8	-1,8	95,9	-99,6	95,9	0,0
321	Natural grasslands	486,7	486,7	0,0	87,9	-81,9	2721,4	2996,0	3013,2	10,7
			structural changes (decreases)			structural changes (increases)			no change	

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Source: Authors' own research.

The analysis of spatial patterns in land usage reveals significant variations in emerging processes across the urban-rural interface. Notably, the most substantial transformations in functional usage were observed within the initial urban development around Bucharest itself. In this area, agricultural land was converted for the development of new residential neighbourhoods, economic activities (e.g. warehousing and production spaces), and infrastructure projects (e.g. highways, express roads, and national roads). These projects, including the construction of bypasses to existing networks, resulted in the creation of new economic development opportunities.

Consequently, pressure on agricultural land extended beyond this initial area to the administrative boundaries of Ilfov County.

The perpetual expansion of built-up areas and the constant demand for accessibility to the polarising urban centre have resulted in the occupation of agricultural land, principally in the immediate vicinity of transport infrastructure.

A quantitative comparison of the situation in 1990 with the present situation in 2018 reveals a maintenance of forested areas, primarily due to the declaration of these areas as protected zones. Additionally, there has been a relocation of industrial areas to agricultural zones, driven by the lower cost of these lands. It is evident, moreover, that there has been a general expansion of residential areas (Figure 2).

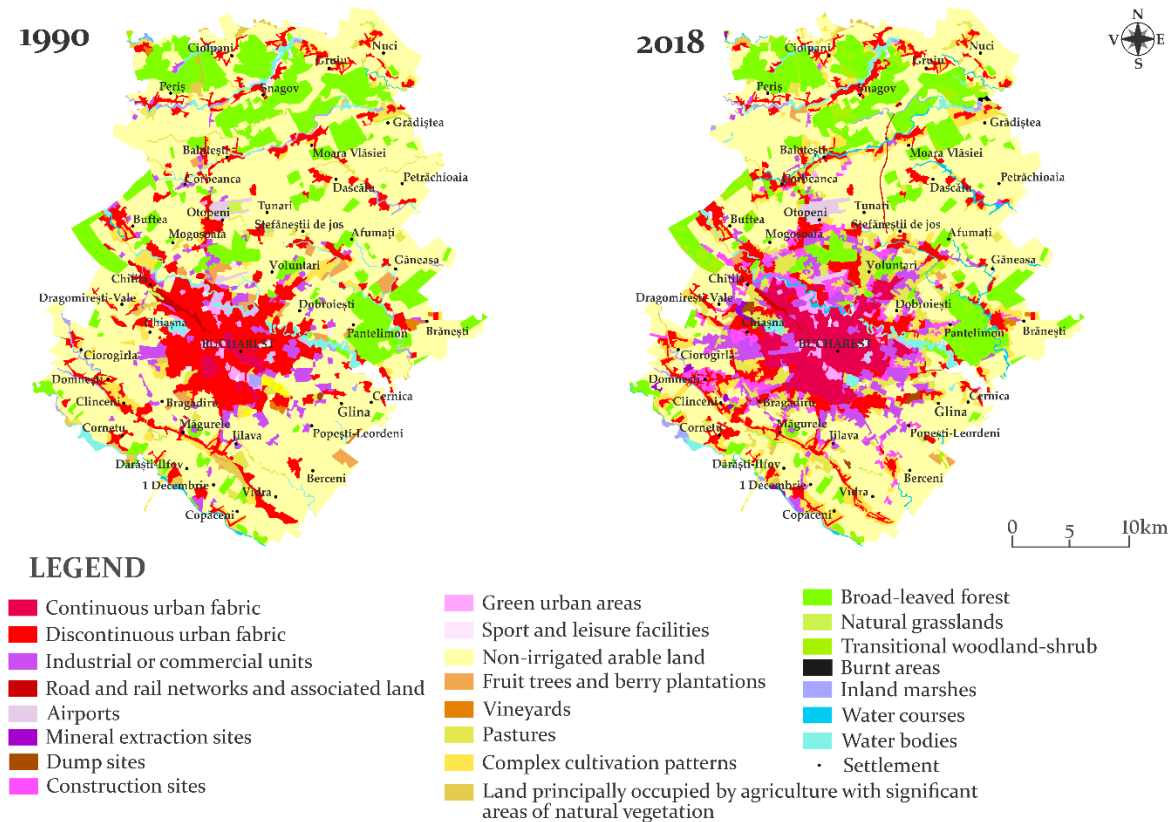


Figure 2. Land use in the emerging territorial system of Bucharest, with a particular focus on the years 1990 and 2018.

Data source: <https://land.copernicus.eu/en/products/corine-land-cover>

In terms of spatial considerations, there is an absence of spatial legality with regard to the extension of built-up areas, resulting in significant economic losses and considerable discomfort for economic agents and the resident population in these newly developed habitable spaces. The agricultural areas are instrumental in ensuring the supply of fresh produce to consumers in Bucharest. A reduction in the surface area of this land, a decrease in water resources and an increase in transportation times for perishable goods will lead to a decrease in the quantities of fresh produce delivered to consumers and, consequently, an increase in the prices of these products.

Changes in functional capacity among diverse land use classifications can be discerned through quantitative assessments. However, the visual representation through graphical methods

offers an equally compelling interpretation. The land use category of arable land has undergone the most significant decrease in spatial extent, witnessing a transition towards alternative uses such as grassland, compact or fragmented urban or industrial zones (Figure 3). A notable transition in functional capacity is the shift from fragmented urban to compact urban zones, a phenomenon that is manifest in spatial land use configurations.

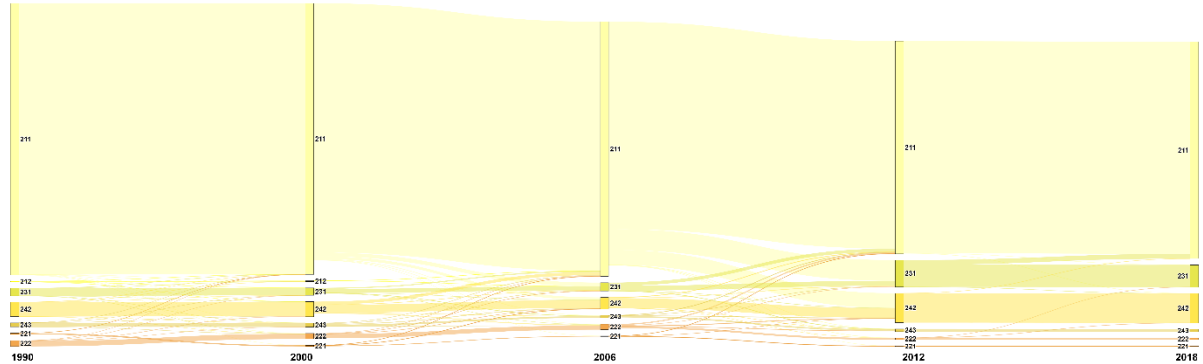


Figure 3. Structural dynamics of land use in the emerging territorial system Bucharest

211- Non-irrigated arable land; 212- Permanently irrigated land; 221- Vineyards;
222- Fruit trees and berry plantations; 231- Pastures; 242- Complex cultivation patterns;
243- Land principally occupied by agriculture, with significant areas of natural vegetation.

Data source: Authors' own research.

The results show the need for intelligent planning of emerging spaces to prevent the negative effects of uncontrolled urban sprawl. Such an approach should be based on methodologies that capture the systemic impact of structural changes in land use patterns (Peptenatu et al., 2012; Ianoș et al., 2012; Drăghici et al., 2015; Andronache et. al., 2016; Herman et al., 2020). The development of relevant methodologies is limited by the lack of statistical data at a high level of granularity. In addition, the approach proposed in this study also contributes to the development of established methodologies for the analysis of emergent processes in territorial systems (Peptenatu et al., 2020; Diaconu et al., 2017, 2019; Gruia et al., 2019). The results obtained may contribute to the development of new research directions of emerging territorial systems, one of which is the construction of models for forecasting the evolution of local economies based on the changes imposed by the polarizing urban center.

Conclusion

A conclusion section is required. Conclusions should provide a synthesis of the main contributions of the paper, discussing the importance of the work, and/or suggest possible applications and extensions of the research. Also, the author should indicate some major limitations of the present research.

The present study aims to provide an analytical perspective on the contemporary situation by conducting a territorial analysis of the ongoing transformation from an agricultural to a built-up area.

The objective of this study is to serve as a foundation for the formulation of novel territorial management plans for the emerging Bucharest area. This undertaking aims to identify the deficiencies inherent in the prevailing developmental mode, as well as to capitalise on the

prevailing opportunities, chiefly the imminent utilisation of the Dâmbovița River as a transportation route for heavy goods and the development of a new passenger airport.

Agricultural land represents the land category most adversely affected by accelerated urban expansion. A considerable proportion of arable land has been converted for use as residential neighbourhoods, logistics facilities, industrial parks or road infrastructure, reflecting the evolving economic and social priorities of the region. Concurrently, there has been an increase in areas designated for grassland or shrubland, representing a transitional phase between agricultural and urbanised areas.

Nevertheless, the research is subject to certain limitations, primarily due to the absence of integration of socio-economic and political factors into the analysis, and the necessity for more detailed causal analysis. The current limitations identified in the research could, however, offer interesting future opportunities for further research on this phenomenon.

In conclusion, the results provide a more nuanced understanding of land use dynamics in the context of accelerated urbanization in the emerging urban space of Bucharest. The findings also highlight the need for sustainable territorial planning that maintains a balance between economic development, urban development and long-term environmental sustainability.

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