COMPARATIVE STUDY OF SUSTAINABLE AGRICULTURE IN ROMANIA AND SERBIA

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Abstract

This paper examines sustainable agriculture in Romania and Serbia through a dual analytical framework. A bibliometric analysis for the period 2000-2025 identifies research trends and thematic clusters based on 249 articles indexed in the Web of Science Core Collection. In parallel, a comparative assessment for 2015-2023 evaluates key agricultural indicators using data from the World Bank. The main goal of the study is to analyze the evolution of scientific interest in sustainable agriculture and to highlight the dominant research themes in both countries. A second goal is to compare structural and economic changes in their agricultural sectors, emphasizing similarities, differences, and long-term sustainability trends. The results show a marked increase in publications after 2018, with Romania contributing the largest share of research output. The comparative indicators reveal declining shares of agriculture in GDP and employment, relatively stable agricultural land use, and growth in fertilizer consumption. These findings indicate gradual modernization but also persistent disparities between Romania and Serbia in their transition toward sustainable agriculture.

Key words: Sustainable agriculture, Romania, Serbia, bibliometric analysis, agriculture indicators, development.

JEL[5]: C82, Q01, Q18

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Introduction

Sustainable agriculture has become a central component of contemporary development strategies, aiming to balance economic productivity, social equity, and environmental protection (Pretty, 2008; Amirova et al., 2022). It ensures long-term food security and resource efficiency while maintaining ecological balance and rural viability (Birovljev, Kleut, 2016; Terán Samaniego et al., 2025; Chen et al., 2025). According to Popović et al. (2015), both Romania and Serbia face common challenges in integrating sustainable land and resource management within broader European frameworks, particularly regarding alignment with the EU's Common Agricultural Policy (CAP). These challenges are amplified by structural economic transitions and rural depopulation, which directly influence the sustainability of agricultural systems (Bogdanov et al., 2017).

Agriculture remains a key sector in both countries, contributing significantly to employment and rural livelihoods. Jeločnik et al. (2015) emphasize that Romania and Serbia possess favorable natural conditions and traditional farming systems that support the development of sustainable and organic agriculture. The authors also note that technological modernization, market adaptation, and policy harmonization with EU standards are essential for achieving long-term agricultural sustainability (Jelocnik et al., 2011).

Similarly, Antić et al. (2017) and Malinić et al. (2025) highlight the close interrelation between demographic change, environmental pressures, and economic restructuring in Serbia's rural areas, pointing out that sustainable rural development requires tailored regional strategies that account for diverse local conditions (Balaban et al., 2019). More recent evidence from Radović et al. (2024) and Dimitrijević et al. (2025) underlines the importance of sustainable financing mechanisms and policy instruments to strengthen the competitiveness and environmental responsibility of agricultural systems in the Western Balkans. At the regional level, Lukšić et al. (2022) further emphasize the role of innovative financial instruments and EU-supported governance mechanisms in advancing sustainable development objectives across the Western Balkans.

Comparative sustainability research on Romania and Serbia shows that both countries share similar environmental pressures and modernization requirements but differ significantly in institutional capacity and alignment with EU frameworks. Studies from related sectors, such as sustainable forest management, highlight Romania's more coherent regulatory system and EU-supported monitoring mechanisms, while Serbia progresses through gradual policy harmonization (Radosavljević, 2023; Vasić, Enescu, 2025). These structural similarities and differences justify a comparative

assessment of agricultural sustainability, where both countries face parallel socio-economic challenges but follow distinct institutional trajectories (Jurjević et al., 2022; Manta et al., 2024).

Building on this literature, the present study examines the evolution of sustainable agriculture in Romania and Serbia between 2000-2025 through a dual analytical framework. A bibliometric analysis identifies research trends and thematic clusters related to sustainable agriculture, while a comparative assessment using World Bank indicators evaluates key aspects of agricultural performance. The approach provides a comprehensive perspective on progress and disparities in the transition toward sustainable agriculture in both countries.

Research Methodology

The study is structured around a dual methodological framework that combines a bibliometric analysis with a comparative evaluation of agriculture indicators. The first component consists of a bibliometric analysis covering the period 2000-2025. Records were extracted from the Web of Science Core Collection using the search terms "sustainable agriculture" and Romania or Serbia, which resulted with 249 publications in database. The database was exported in plain text format and processed with VOSviewer to identify co-occurring author keywords and citation relationships. Tableau software was used to visualize the annual evolution of publications and the geographical distribution of research output. Although the mapping function displays all countries present in the database, the analytical focus remains on Romania and Serbia.

The second component of the methodology consists of a comparative assessment of agricultural performances in Romania and Serbia, for the period 2015-2023. This analysis relies on indicators retrieved from the World Bank's World Development Indicators database. Four variables were selected to capture structural and economic transformation relevant for sustainable agriculture: "agriculture, forestry, and fishing value added as a share of GDP"; "agricultural land as a percentage of total land area"; "employment in agriculture as a share of total employment"; and "fertilizer consumption measured in kilograms per hectare of arable land".

The methodological approach entails several limitations. The bibliometric analysis relies exclusively on publications indexed in the Web of Science Core Collection, which may result in the omission of relevant regional or non-indexed studies. The keyword-based search strategy may have excluded studies addressing sustainability implicitly or under related conceptual frameworks.

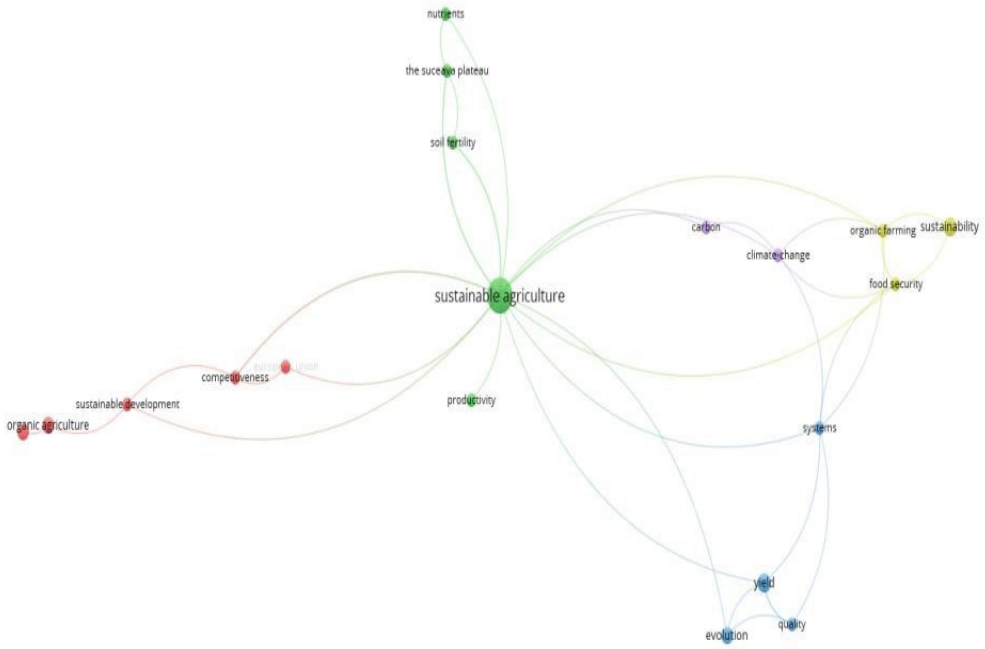
The comparative analysis depends on aggregated World Bank indicators, which do not capture local or intra-regional disparities. Furthermore, differences in data availability limit the comparative period to 2015-2023.

Research Results

The research results are presented in two complementary parts, corresponding to the methodological framework described above. The first part reports the findings of the bibliometric analysis conducted for the period 2000-2025, including the most frequent author keywords, the evolution of scientific output, and the geographical distribution of publications related to sustainable agriculture. The second part presents the comparative results for Romania and Serbia based on World Bank indicators for 2015-2023, highlighting structural and economic trends in their agricultural sectors. Together, these results contribute to a border understanding of scientific interest in sustainable agriculture and the measurable transformations observed in the two countries.

Bibliometric analysis

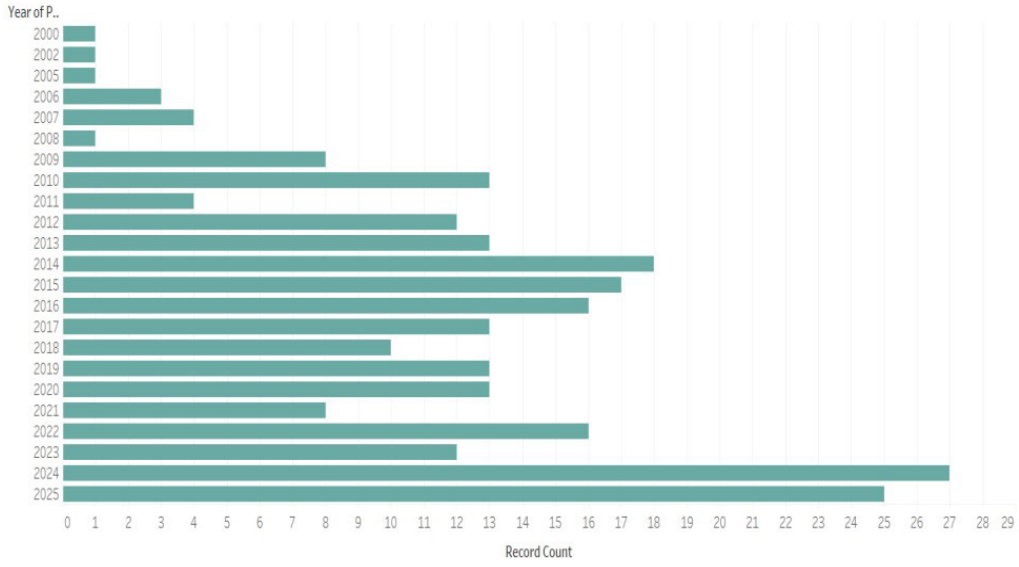
Figure 1. Author keyword co-occurrence map



Source: Own elaboration using VOSviewer

The most cited keywords (minimum of two occurrences) include terms such as sustainable agriculture, productivity, climate change, competitiveness, food security and organic agriculture (Figure 1.). It is noteworthy that country names are frequently absent from the author keyword field, even in studies explicitly focused on those countries.

Figure 2. Evolution of publications on sustainable agriculture related to Romania and Serbia (2000-2025)



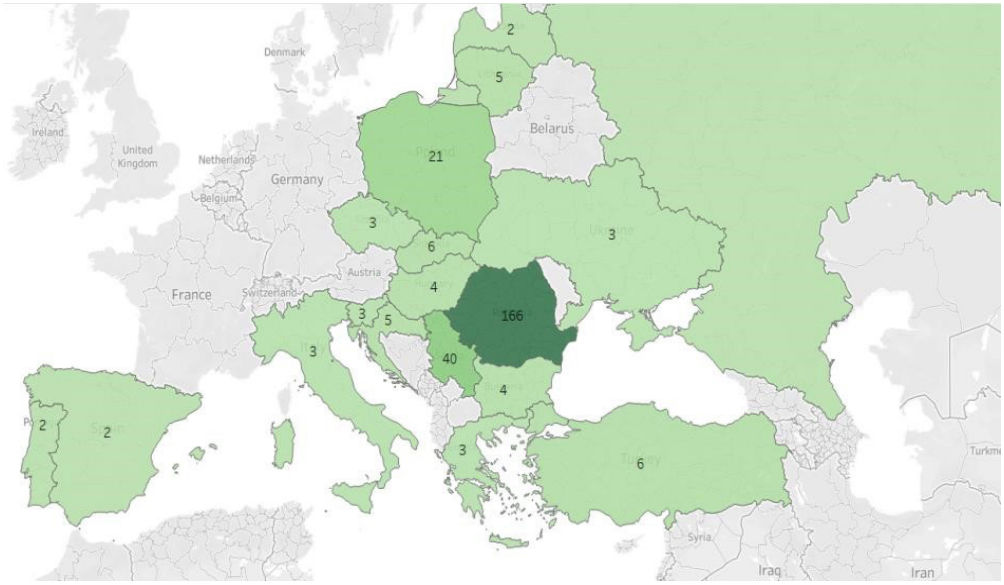
Source: Own elaboration using Tableau software.

Figure 2. shows the annual distribution of publications on sustainable agriculture related to Romania and Serbia for the period 2000-2025. The pattern is oscillatory, with alternating increases and decreases rather than a continuous upward trend. After 2010, publication activity became more visible, but fluctuations remained present throughout the period. A more pronounced rise appears only toward the end of the interval, with the highest publication counts recorded in 2024 and 2025, which exceed the values observed in 2023. Despite the year-to-year variability, the long-term trend line indicates a gradual increase in scientific interest in sustainable agriculture in Romania and Serbia.

Figure 3. presents the geographical distribution of publications on sustainable agriculture that specifically address Romania and Serbia. Romania accounts for 166 papers (66% of overall number of papers), followed by Serbia with 40 publications (16,1%) and Poland with 21 (8,4%). Other countries, including Slovakia, Turkey,

Lithuania, and Croatia, contribute between 2% and 3% each. The lower representation of Western and Northern European countries results from the fact that the database includes only publications that explicitly address Romania or Serbia. In this sense, the figure reflects the distribution of publications that address Romania and Serbia, rather than the broader European research output on sustainable agriculture.

Figure 3. Geographical distribution of publications on sustainable agriculture related to Romania and Serbia



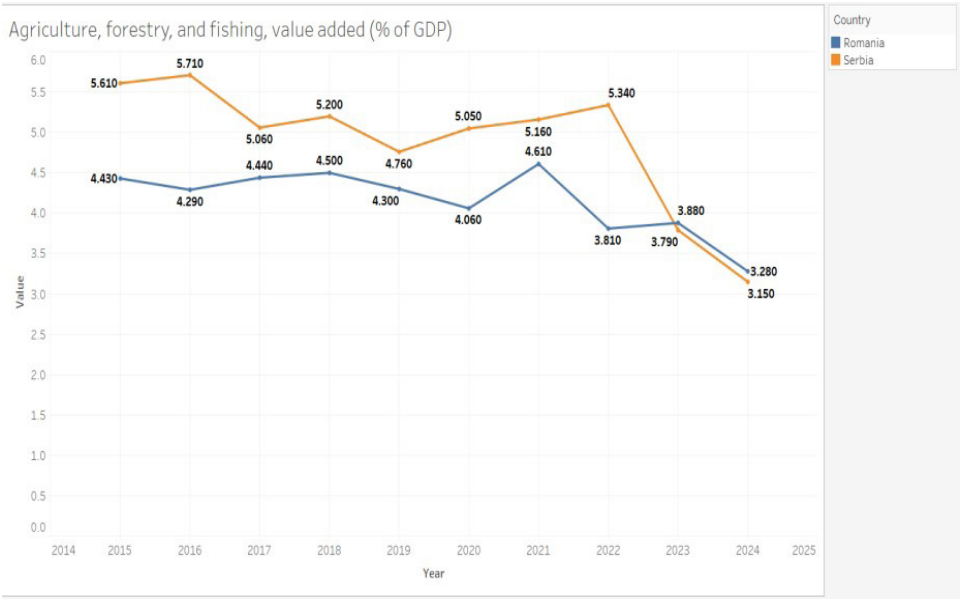
Source: Own elaboration using Tableau software

Analysis of sustainability-related agricultural indicators in Romania and Serbia

To complement the bibliometric analysis, which highlights the main research directions and thematic focus of existing studies on sustainable agriculture in Romania and Serbia, a set of quantitative indicators was selected to assess the evolution of key structural dimensions of the agricultural sector over time. These indicators capture selected economic, land-use, employment and input-use characteristics of the sustainability and agriculture sector in both countries.

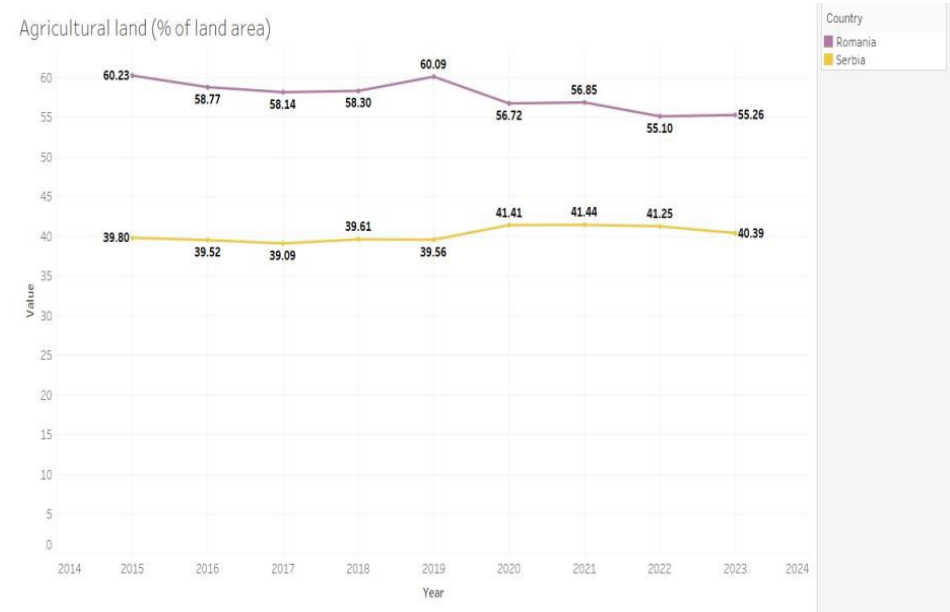
Agriculture, forestry, and fishing value added as a share of GDP shows a gradual decline, both in Romania and Serbia, between 2015 and 2024. In Romania, the share decreased from 4.43% in 2015 to 3.28% in 2024, while in Serbia it fell from 5.61% to 3.15% (Figure 4.). This downward trend reflects the ongoing structural transformation of both economies, where agriculture becomes relatively less dominant as sectors with higher value added expand, an evolution generally associated with long term sustainability and modernization.

Figure 4. Agriculture, forestry, and fishing, value added (in % of GDP), in Romania and Serbia, 2015-2024



Source: Own elaboration using Tableau software, according to WB, 2025a.

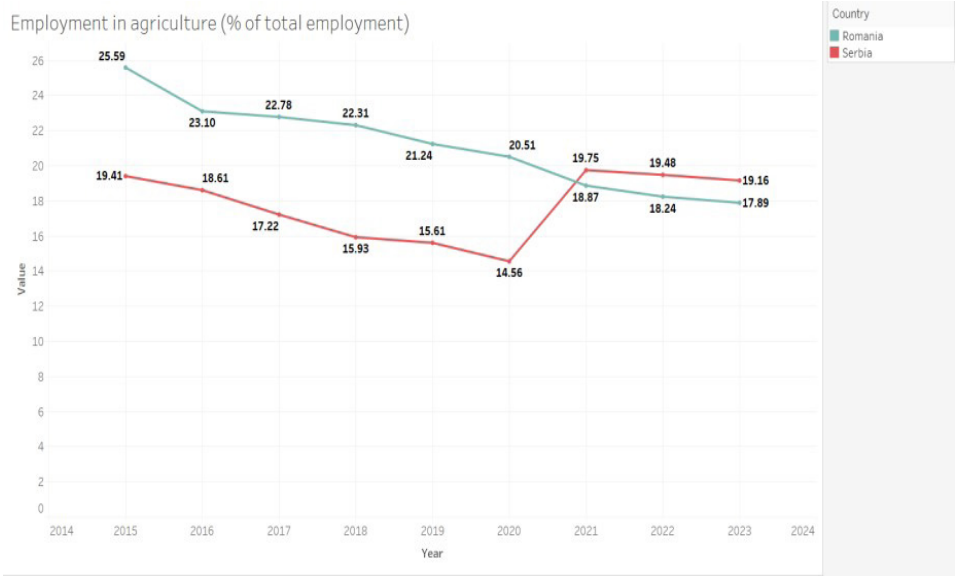
Figure 5. Agricultural land as a share of overall land area (in %), in Romania and Serbia, 2015-2023



Source: Own elaboration using Tableau software, according to WB, 2025b.

The share of agricultural land in total land area remained relatively stable in both countries between 2015 and 2023, yet distinct structural profiles (Figure 5.). In Romania, agricultural land accounted for around 60% in 2015 but gradually declined to 55.3% by 2023, suggesting moderate land-use reduction and possible reallocation toward non-agricultural purposes. In Serbia, the share fluctuated only slightly between 39% and 41%, indicating a more stable land-use structure. From a sustainability perspective, these patterns suggest that land availability alone does not constitute the main factor driving structural change in either country. Considered alongside the declining contribution of agriculture to GDP and the still relatively high share of sectoral employment, the data indicate potential disparities between resource use and economic output. Such structural imbalances may point to efficiency constraints and highlight the relevance of improved productivity and more sustainable land-management practices (Miljković, Crnčević, 2022; Sălășan et al., 2025).

Figure 6. Employment in agriculture as a share of total employment (%) in Romania and Serbia, 2015-2023

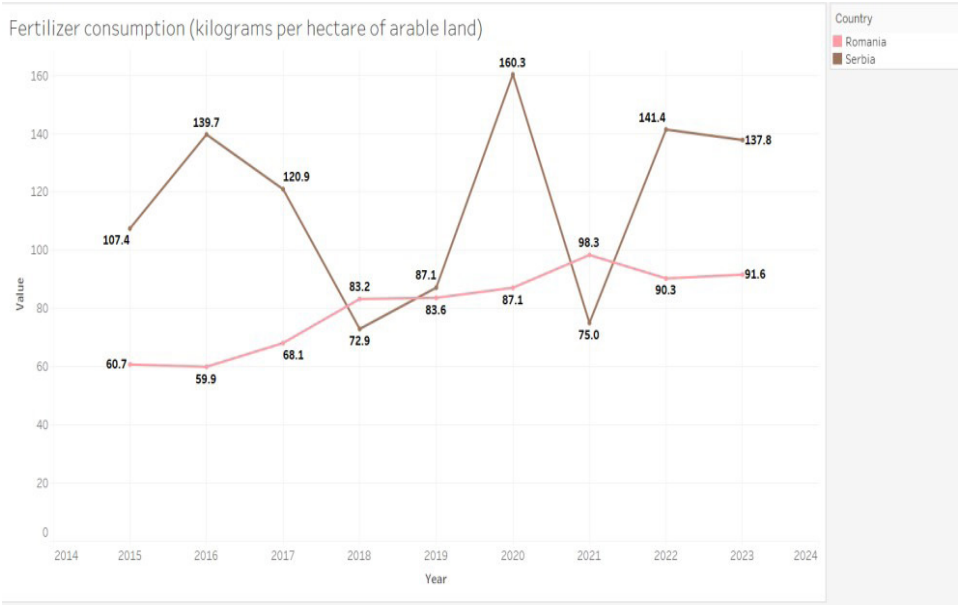


Source: Own elaboration using Tableau software, according to WB, 2025c.

Employment in agriculture as a share of total employment shows a consistent downward trajectory in both countries, reflecting ongoing structural transformation toward non-agricultural sectors (Figure 6.). In Romania, the share declined markedly from 25.6% in 2015 to 17.9% in 2023, evidencing accelerated labor reallocation and rural depopulation trends. Serbia followed a similar but less pronounced path, decreasing from 19.4% to 15.6% by 2019, with a temporary rebound to around 19% after 2021. This post 2021 increase should not be interpreted as a structural

return to agriculture, but rather as a short-term adjustment possibly influenced by pandemic related labor market disruptions and reduced employment opportunities in other sectors.

Figure 7. Fertilizer consumption (kg/ha of arable land), in Romania and Serbia, 2015-2023.



Source: Own elaboration using Tableau software, according to WB, 2025d.

Usually, intensification of conventional agriculture is considered through increased appliance of agro-inputs, such as agro-chemicals (fertilizers and pesticides), (Pretty, Bharucha, 2014; Ion, 2020). Fertilizer consumption per hectare increased overall in both countries, reflecting the intensification in agricultural practices (Figure 7.). In Romania, application of fertilizers rose steadily from 60.7 kg/ha in 2015 to about 91.6 kg/ha in 2023, indicating gradual technological upgrading and input intensification. Such developments can only indirectly signal modernization, as fertilizer use per hectare captures quantitative intensity rather than qualitative improvements in production systems (Popescu et al., 2021; Zhang et al., 2022).

Serbia displayed higher but more volatile values, ranging from 72.9 kg/ha in 2018 to peaks above 160 kg/ha in 2020. The pronounced increase in 2020 may be associated with short-term market and policy factors rather than a structural shift in agricultural orientation. The subsequent decline after 2021 reflects input price volatility and market adjustment effects (Đurić et al., 2019). As a quantitative indicator of input intensity, fertilizer consumption per hectare offers limited evidence on productivity, sustainability, or modernization in the absence of structural data.

Conclusion

This study offers a comprehensive examination of sustainable agriculture in Romania and Serbia through two complementary approaches. The bibliometric analysis covering 2000-2025 revealed a steady increase in research output after 2018, indicating a growing academic interest in observed field.

The comparative analysis of World Bank indicators for 2015-2023 highlights parallel structural trends in both economies. The share of agriculture in GDP and employment declined steadily, reflecting modernization and a gradual shift toward non-agricultural activities. Agricultural land use remained relatively stable, while fertilizer consumption increased, indicating intensified production and input-driven growth. Both countries show measurable progress toward more efficient and modern agricultural systems, achieving long-term sustainability that requires coherent rural policies and balanced resource management aligned with European sustainability objectives.

The scientific relevance of research lies in its integrated approach, which connects academic discourse with measurable structural developments, offering a clearer understanding of how sustainability is evolving in two comparable agricultural systems. The findings can support policymakers in designing targeted rural development strategies, improving resource allocation and strengthening the coherence of national policies. These conclusions are consistent with broader evidence from the literature, which shows that Serbia's agricultural sector continues to face structural constraints such as fragmented land, low productivity, inconsistent agricultural policies and limited investment capacity, all of which hinder long-term com competitiveness and sustainability (Aničić et al., 2025). This alignment reinforces the practical importance of the present study, as it highlights how both countries must address similar structural challenges to advance toward European sustainability objectives.

Subsequent research may integrate additional environmental metrics and comparative analyses to provide deeper insights into regional agricultural development.

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