

CIRCULAR ECONOMY IN ROMANIAN AGRICULTURE: COMPARATIVE INSIGHTS FROM THE EUROPEAN UNION

RUSU ANDREI^{*1}, MARTIN ANAMARIA ROXANA¹, IANCU TIBERIU¹,
ADAMOV TABITA CORNELIA¹

¹University of Life Sciences “King Michael I of Romania” from Timisoara, Faculty of
Management and Rural Tourism

*Corresponding author’s e-mail: andrei.rusu.fmtr@usvt.ro

Abstract: This study analyses the integration of circular economy principles in Romanian agriculture by comparing resource efficiency with European Union trends. Using statistical data from Eurostat, the European Environment Agency and national sources, the analysis covers indicators such as circular material use, waste generation and recycling, biomass utilisation and organic farming. The results show that, despite Romania’s potential for circularity through biomass and organic waste valorisation, its circular material use rate remains among the lowest in the EU. Structural barriers, including limited investment, low innovation uptake and weak rural waste management infrastructure, continue to constrain progress. Nevertheless, EU policy frameworks such as the Green Deal and Farm to Fork strategy offer important opportunities for advancing circular practices and improving sustainability in Romanian agriculture.

Key words: circular economy, agriculture, resource efficiency, biomass, recycling

INTRODUCTION

The circular economy represents a key pillar of the European Union’s strategy for achieving sustainable development, aiming to promote resource efficiency, reduce waste generation, and minimize environmental impact. Unlike the traditional linear model of “take-make-dispose,” the circular approach focuses on reuse, recycling, and the regeneration of natural systems, ensuring that materials remain in use for as long as possible. Within the framework of the European Green Deal and the Circular Economy Action Plan (2020), the EU has prioritized the transition toward circularity across all sectors, with agriculture playing an essential role in this transformation [5, 6].

In Romania, agriculture remains one of the most resource-intensive economic sectors, facing increasing pressure to adopt more sustainable production systems. The national economy benefits from rich biological and renewable resources, yet the adoption of circular practices, such as nutrient recycling, organic waste valorization, renewable bio-based inputs, and organic farming, is still at an early stage compared to the EU average. These challenges underline the importance of evaluating how circular principles are integrated into Romania’s agricultural strategies and how they contribute to both economic resilience and environmental protection [3,15,17].

The objective of this study is to analyze the level of implementation of circular economy principles in Romanian agriculture, using a set of comparative indicators derived from Eurostat, the European Environment Agency (EEA), the Research Institute of Organic Agriculture (FiBL), and the Romanian Ministry of Agriculture and Rural Development (MADR) [15,17]. The analysis focuses on key variables such as the Circular Material Use Rate, Waste Generation, Recycling Rate, Biomass Utilization, and Organic Farming Area.

The novelty of this research lies in integrating environmental and socio-economic indicators to illustrate Romania’s progress toward circular agriculture in line with the EU’s sustainability objectives. The analysis also acknowledges certain limitations arising from the availability and comparability of statistical data across member states [7,8].

Ultimately, this paper aims to contribute to a deeper understanding of how the circular economy can support the sustainable transformation of Romanian agriculture,

fostering innovation, competitiveness, and alignment with the European Union's long-term vision for a climate-neutral, resource-efficient future [6].

MATERIALS AND METHODS

The study is based on a comparative analysis of statistical and documentary data concerning the implementation of circular economy principles in Romanian agriculture in relation to the European Union average. Official data were collected from Eurostat, the European Environment Agency (EEA), the Research Institute of Organic Agriculture (FiBL), and the Romanian Ministry of Agriculture and Rural Development (MADR) for the period 2010–2023. The analysis focused on several key indicators, including the Circular Material Use Rate, Waste Generation, Recycling Rate, Biomass Utilization, and Organic Farming Area. Descriptive and comparative methods were applied to identify trends and differences between Romania and the European Union, highlighting progress toward sustainability and circularity in the agricultural sector.

RESEARCH RESULTS

The transition to a circular economy across the European Union aims to improve resource efficiency by increasing the share of materials reused or recycled in production processes. In this context, the analysis of Romania's performance highlights a persistent gap compared to the EU average, with progress remaining limited in recent years [8].

According to Eurostat (2024), the Circular Material Use Rate (CMU) in Romania was only 1.3% in 2023, indicating that a very small proportion of materials re-enter production cycles as secondary resources. This value is far below the EU average of 11.8%, and considerably lower than in advanced economies such as Italy and the Netherlands, where circular material use exceeds 20–30% [8]. The data show that Romania's CMU slightly decreased over the last decade, from approximately 3.5% in 2010, while the European average increased moderately from 10.7% to 11.8% during the same period. Figure 3.1 presents the evolution of the circular material use rate between 2010 and 2023, comparing Romania with the EU average and selected countries.

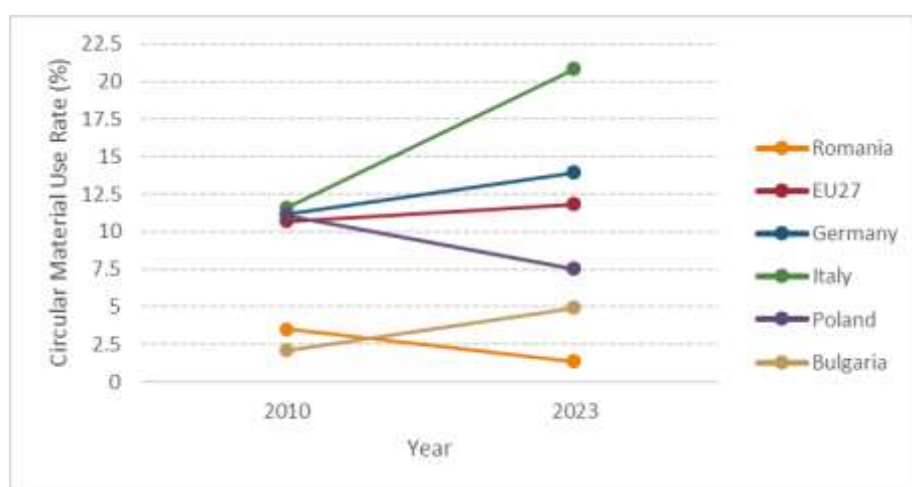


Figure 1. Evolution of the Circular Material Use Rate (2010–2023), Romania vs EU and selected countries (Germany, Italy, Poland, Bulgaria)

Source: Eurostat (2024), European Environment Agency (EEA, 2024)

In parallel, Romania also records low values for resource productivity, defined as economic output per kilogram of material consumed. Between 2010 and 2022, this indicator stagnated between 0.3–0.6 EUR/kg, while the EU average rose to 6.4 EUR/kg

[9]. This means that Romania produces almost ten times less economic output for each kilogram of material used compared to the Union average. Furthermore, the material footprint, which measures the total material consumption per capita, reaches nearly 30 tonnes per person in Romania, approximately double the EU average of 15 tonnes [10]. These results illustrate that Romania’s economy continues to depend heavily on virgin raw materials and has a limited capacity to reintegrate recycled inputs into production systems.

Table 1.
Circular Economy and Resource Efficiency Indicators, Romania vs EU (2010–2023)

Indicator	Unit	Romania 2010	Romania 2023	EU-27 2010	EU-27 2023
Circular Material Use Rate (CMU)	%	~3.5	1.3	10.7	11.8
Resource Productivity	EUR/kg	0.50	0.38	1.8	2.13
Material Footprint	tonnes/capita	—	30.0	—	15.0

Source: Eurostat (2024), EEA (2024), Interreg (2024)

Following the analysis of material efficiency, the study also examines waste generation as a key indicator of circular performance across the European Union. The management of waste is a central component of the circular economy, reflecting the capacity of societies to reduce, reuse, and recycle materials instead of disposing of them [2].

According to Eurostat (2024), the amount of municipal waste generated per capita in Romania remains below the European average, although it has shown a gradual upward trend over the last decade. In 2023, Romania generated approximately 305 kg per capita, compared to the EU-27 average of 511 kg per capita. This value is considerably lower than in Western Member States such as Germany (613 kg) and Italy (489 kg), and is comparable to levels observed in Poland (367 kg) and Bulgaria (490 kg) [11, 13]. These data confirm that, although Romanian households generate less waste than the EU average, the volume of waste has been increasing steadily, reflecting changing consumption patterns and limited progress in waste prevention.

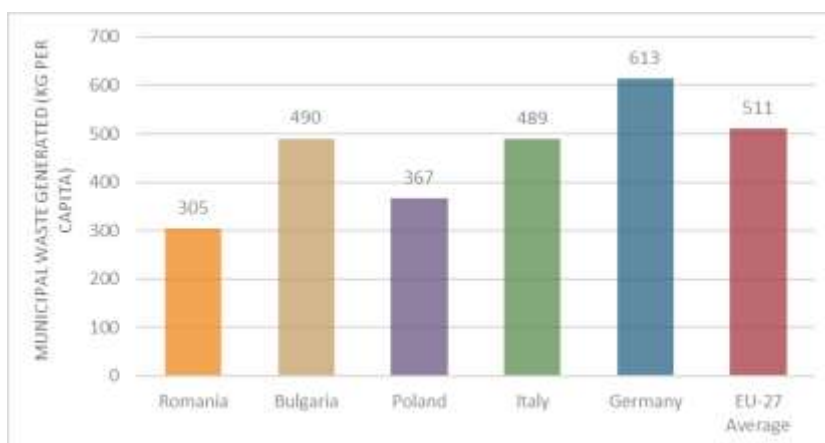


Figure 2. Municipal Waste Generation per Capita (2023), Romania vs EU and selected countries (Germany, Italy, Poland, Bulgaria)

Source: Source: Eurostat (2024), dataset env_wasmun - Municipal waste by waste management operations

Despite the relatively low amount of waste generated, Romania’s recycling performance remains one of the weakest in the European Union. According to Eurostat (2024), in 2023 the municipal waste recycling rate in Romania was only 12.4%, compared

to the EU-27 average of 47.7%. This gap illustrates the country's limited capacity to implement effective waste sorting, collection, and recovery systems [10, 12].

Western Member States such as Germany (68.7%) and Italy (50.8%) have achieved much higher recycling rates, while Poland (27.6%) and Bulgaria (16.7%) show intermediate results. The persistent disparity across Europe reflects differences in infrastructure, policy enforcement, and public awareness. Figure 3 highlights these variations, placing Romania among the lowest performers in the EU in 2023 [12].

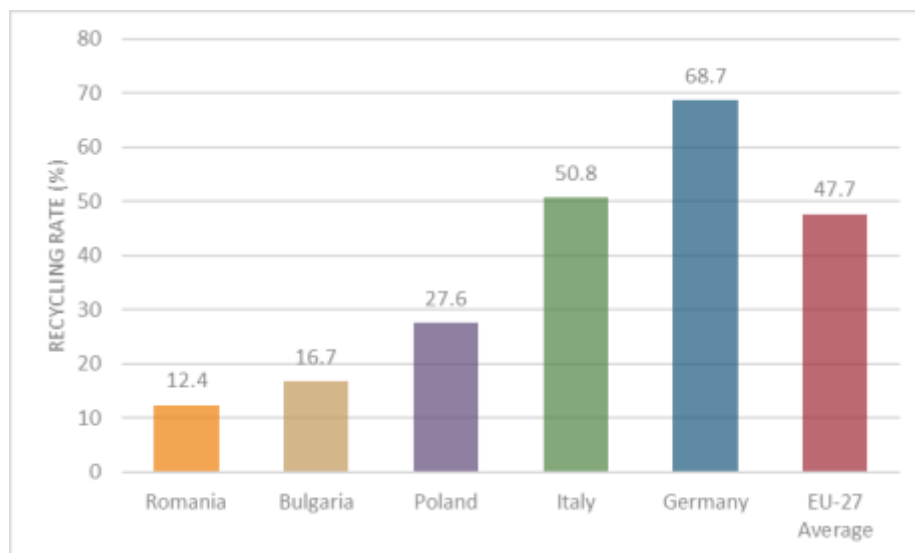


Figure 3. Recycling Rate of Municipal Waste (% of total generated, 2023), Romania vs EU and selected countries (Germany, Italy, Poland, Bulgaria)

Source: Eurostat (2024), dataset *cei_wm011 - Recycling rate of municipal waste*

In parallel, Romania continues to rely heavily on landfilling as the dominant method of waste disposal. While the EU average for landfill use has declined significantly in recent years, falling below 20% of total municipal waste, national reports indicate that over 70% of Romania's municipal waste is still sent to landfill sites. This dependence reflects both delayed implementation of EU waste directives and limited national capacity for waste recovery, composting, and incineration with energy recovery. The excessive reliance on landfilling poses serious environmental risks, including soil and water pollution, methane emissions, and the loss of recyclable materials [9, 16].

Beyond municipal waste, packaging waste recycling provides an additional perspective on circular material flows, particularly relevant to the agri-food sector. Packaging represents a key component of resource use in production and distribution chains, and its recovery rate is an important indicator of circular performance. According to Eurostat (2024), in 2023 Romania recycled only 37.3% of packaging waste, compared to the EU-27 average of 67.5%. Western Member States such as Italy (73.9) and Germany (69.4%) report much higher rates, while Poland (67.4%) and Bulgaria (58.3%) also perform substantially better. These results underline persistent challenges in Romania's collection and recycling systems, including inadequate infrastructure, insufficient market demand for secondary raw materials, and low awareness among producers and consumers [13, 14].

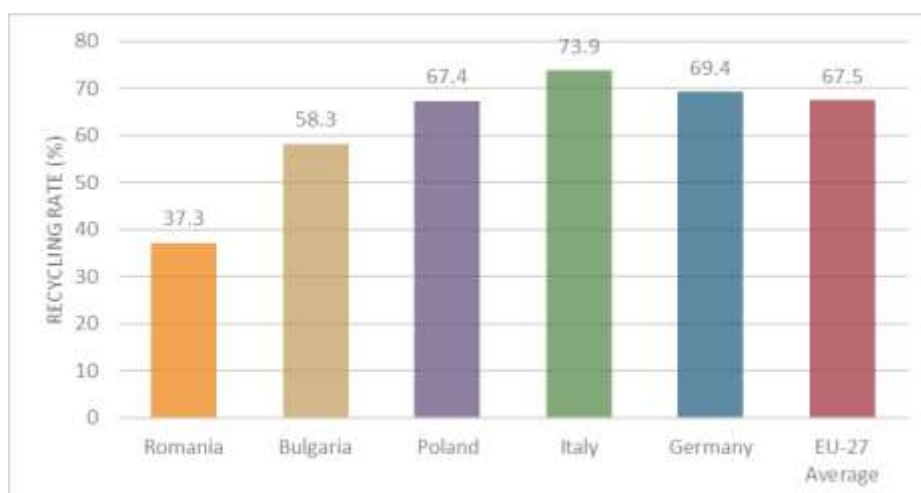


Figure 4. Packaging Waste Recycling Rate (2022), Romania vs EU and selected countries (Germany, Italy, Poland, Bulgaria)

Source: Eurostat (2024), dataset *env_waspac* – Packaging waste by waste management operations

Overall, these findings highlight Romania’s dual position within the EU: generating less waste per capita, but achieving some of the lowest recycling and recovery rates. The data suggest that without substantial improvements in separate collection, recycling infrastructure, and waste valorization technologies, Romania will continue to lag behind EU circular economy objectives. Addressing these challenges requires both increased investment and stronger policy enforcement to shift from a linear “produce–consume–dispose” model toward a sustainable circular system [1, 16].

Table 2.

Waste generation and recycling indicators, Romania vs EU (2010-2023)

Indicator	Unit	Romania 2010	Romania 2023	EU-27 2010	EU-27 2023
Municipal Generation Waste	<i>kg/capita</i>	313	305	503	511
Recycling Rate (Municipal Waste)	%	12,8	12.4	38,8	47.7
Packaging Waste Recycling	%	43,4	37.3	64	67.5
Share of Waste Landfilled	<i>% of total</i>	~85	>70	~45	<20

Source: Eurostat (2024), datasets *env_wasmun*, *cei_wm011*, *env_waspac*; EEA (2024).

The transition toward a more circular and sustainable agricultural system in Romania is closely connected to the expansion of **organic farming** and the valorization of biomass resources. Both processes support the European Union’s environmental objectives under the Green Deal and the Common Agricultural Policy 2023–2027, promoting low-emission and resource-efficient agricultural practices [2, 4, 5].

According to Eurostat (2024), the share of organic farming in Romania increased from **1.3% of the total Utilised Agricultural Area (UAA)** in 2010 to **5.46% in 2023**, marking a fourfold expansion over the last decade. Although this represents significant progress, Romania still remains below the **EU-27 average of approximately 10.6%**, as shown in **Table 3**. Countries such as Italy (18.78%) and Germany (11.16%) have achieved considerably higher levels, supported by consistent policy incentives and strong consumer demand for certified organic products [14,15,17].

Table 3.

Share of organic farming area in total UAA (%), 2010–2023

Country	2010	2023
Romania	1.3	5.46
Germany	5.9	11.16
Italy	8.6	18.78
Poland	3.3	4.35
Bulgaria	0.5	2.95
EU-27	5.1	10.6

Source: Eurostat (2024), dataset sdg_02_40 - Area under organic farming

At the national level, data from the Romanian Ministry of Agriculture and FiBL indicate a notable increase in the certified organic area, from **182,706 hectares in 2010** to **nearly 694,000 hectares in 2023**, while the number of organic operators fluctuated between 3,000 and 15,000 over the same period (Table 4). These variations reflect the influence of subsidy schemes and unstable market demand for organic products [15, 17].

Table 4.

Evolution of organic farming in Romania (2010–2023)

Year	Organic area (ha)	Number of organic operators
2010	182,706	3,155
2012	288,261	15,544
2015	245,923	12,231
2017	258,470	8,434
2020	468,886	10,210
2021	578,727	12,231
2022	644,520	13,260
2023	693,998	14,061

Source: Romanian Ministry of Agriculture and Rural Development (MADR) and FiBL Survey 2024 - The World of Organic Agriculture.

Despite the positive expansion, Romania's organic sector still faces structural and economic challenges. Domestic consumption of organic food remains limited, while most production is exported as raw materials with low added value. The weak development of local processing infrastructure and insufficient access to short supply chains constrain the competitiveness of organic farms.

Furthermore, the adoption of eco-schemes under the CAP 2023–2027 remains partial: only about one-quarter of the eligible area has been registered under these sustainability schemes, often due to complex administrative requirements and low awareness among farmers. The National Strategic Plan 2023–2027 foresees targeted support measures, including financial incentives for organic conversion and investment in local processing capacities, aiming to reach *10% of total agricultural land under organic management by 2030* [1,3].

Parallel to organic farming, the **utilization of biomass resources** holds substantial potential for advancing agricultural circularity. Romania possesses abundant biomass, crop residues, manure, forestry by-products, and food waste, but their economic use remains

limited. Most biomass is consumed in raw form, mainly for household heating, while large-scale biogas and composting facilities are still rare. According to the European Environment Agency (2024), biomass accounts for nearly **90% of Romania's renewable energy mix**, compared with around **60% in the EU-27**, highlighting the country's dependence on unprocessed bioresources [15].

However, this dominance does not necessarily indicate efficiency: the lack of technological integration means that much of the agricultural residue is still burned, discarded, or landfilled, rather than recycled into energy, fertilizers, or bio-based materials. In contrast, Western EU countries, particularly Germany and Italy, have developed thousands of farm-based biogas plants, linking waste management with clean energy production and nutrient recycling.

Overall, Romania's progress toward circular bioeconomy practices remains at an early stage, characterized by extensive but low-efficiency use of biomass. Strengthening investments in biogas infrastructure, composting, and local bioenergy projects, together with improved market access for organic products, could significantly enhance both environmental performance and economic resilience in Romanian agriculture.

The transition toward a sustainable and low-carbon agricultural model is closely connected to the efficient use of resources, the valorization of biomass, and the reduction of **greenhouse gas (GHG) emissions - a central component of environmental performance in European agriculture**.

According to data from the European Environment Agency (EEA, 2024), Romania's agricultural emissions decreased by approximately **13.52%** between 2005 and 2022, exceeding the overall EU-27 reduction of about **5.45%** during the same period. Despite this relatively strong performance, projections suggest a potential reversal of this trend if no additional mitigation measures are implemented. By 2030, *agricultural GHG emissions in Romania* are expected to increase by around 5.72% under existing policies, while the implementation of additional measures could limit the increase to about 3.41%. In contrast, the EU-27 is projected to continue its gradual decline, reaching reductions of 4.16% to 7.37% by 2030 under the same respective scenarios [6, 7].

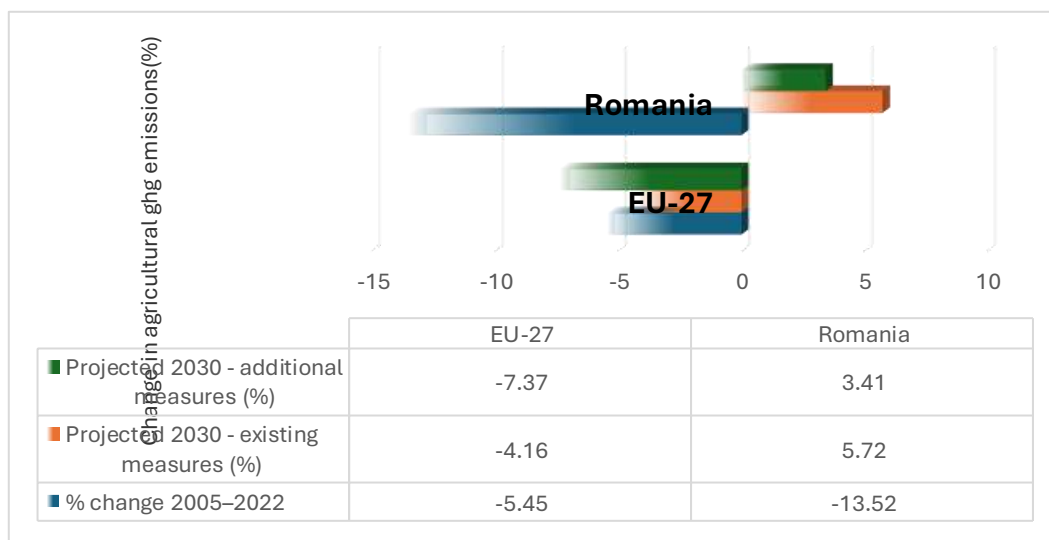


Figure 5. Agricultural GHG Emissions and Projections, Romania vs EU-27 (2005–2030)

Source: European Environment Agency (EEA, 2024)

These contrasting projections reflect Romania's slower progress in adopting advanced emission-reduction technologies, such as precision fertilization, improved manure management, and biogas recovery systems. Structural challenges, including small farm size, limited access to investment capital, and low levels of digitalization, continue to hinder large-scale improvements in emission efficiency. Nevertheless, Romania's previous achievements in reducing GHG emissions demonstrate the country's potential to further align with the EU's climate targets through targeted policy incentives and green transition programs [3,4,17].

As illustrated in Figure 5, the evolution and projected trends of agricultural GHG emissions highlight the dual nature of Romania's agricultural transition: meaningful progress in the past, yet a pressing need for sustained and integrated measures in the future. Strengthening support for low-emission technologies, expanding biogas infrastructure, and improving carbon management in soils and fertilizers will be essential to achieving long-term climate resilience and competitiveness within the European agricultural system.

CONCLUSIONS

The analysis conducted in this study highlights Romania's gradual but uneven transition toward a circular and sustainable agricultural model within the European framework. While progress has been recorded in specific areas, such as reduced waste generation, improved recycling infrastructure, and the expansion of organic farming, Romania continues to face persistent structural and technological gaps compared to the EU average.

The comparative assessment of circular economy indicators demonstrates that Romania's agricultural system remains highly resource-intensive, with low material reuse and limited waste valorization. Despite positive trends in municipal waste management and packaging recycling, the country's overall recycling rates remain among the lowest in the European Union, reflecting delayed implementation of waste recovery technologies and insufficient policy enforcement. Similarly, the slow development of the organic farming sector, coupled with underutilization of biomass resources, points to limited integration of circular principles into production and distribution chains.

From a climate perspective, agricultural greenhouse gas emissions have shown a moderate decline since 2005, yet projections suggest a possible reversal of this trend if mitigation measures are not strengthened. The data confirm that Romania's agriculture is still characterized by high dependence on conventional practices and low adoption of low-emission technologies such as precision fertilization, manure recovery, and biogas systems.

Overall, the findings underline the need for consistent and long-term policy efforts to accelerate Romania's agricultural transition toward circularity. Strategic investments in waste recovery infrastructure, renewable energy, organic production, and sustainable soil management are essential to enhance both environmental performance and economic competitiveness. Strengthening cooperation between policymakers, farmers, and research institutions will play a decisive role in achieving the objectives of a resilient and climate-neutral agricultural sector aligned with the European Green Deal.

REFERENCES

- [1]. **IAGĂRU R., ȘIPOȘ A., IAGĂRU P.**, 2023, Strategic Thinking and Its Role in Accelerating the Transition from the Linear to the Circular Economic Model—Case Study of the Agri-Food Sector in the Sibiu Depression Microregion, Romania, *Sustainability*, vol. 15(4)
- [2]. **KIRCHHERR J., PISCICELLI L., BOUR R., KOSTENSE-SMIT E., MULLER J., HUIBRECHTSE-TRUIJENS A., HEKKERT M.**, 2018, Barriers to the Circular Economy: Evidence from the European Union, *Ecological Economics*, vol. 150, pp. 264–272
- [3]. **MIHAI F.C.**, 2023, Circular Economy and Sustainable Rural Development, *Sustainability*, vol. 15(3)
- [4]. **REICHEL A., DE SCHOENMAKERE M., GILLABEL J.**, 2016, Circular Economy in Europe – Developing the Knowledge Base, European Environment Agency, Luxembourg
- [5]. *** **EUROPEAN COMMISSION**, 2020, Circular Economy Action Plan: For a Cleaner and More Competitive Europe, Brussels
- [6]. *** **EUROPEAN COMMISSION**, 2023, Effort Sharing Regulation (ESR) and Climate Targets for 2030, Directorate-General for Climate Action (DG CLIMA), Brussels.
- [7]. *** **EUROPEAN ENVIRONMENT AGENCY (EEA)**, 2024, Agricultural Greenhouse Gas Emissions and Projections (2005–2030), European Environment Agency, Copenhagen. Available at: <https://www.eea.europa.eu> [Accessed: 02.11.2024]
- [8]. *** **EUROSTAT**, 2024, Circular Material Use Rate (env_ac_curm). Available at: <https://ec.europa.eu/eurostat> [Accessed: 02.11.2024]
- [9]. *** **EUROSTAT**, 2024, Resource Productivity and Domestic Material Consumption (env_ac_rp). Available at: <https://ec.europa.eu/eurostat> [Accessed: 01.11.2024]
- [10]. *** **EUROSTAT**, 2024, Material Footprint (env_ac_mfa). Available at: <https://ec.europa.eu/eurostat> [Accessed: 02.11.2024]
- [11]. *** **EUROSTAT**, 2024, Municipal Waste by Waste Management Operations (env_wasmun). Available at: <https://ec.europa.eu/eurostat> [Accessed: 03.11.2024]
- [12]. *** **EUROSTAT**, 2024, Recycling Rate of Municipal Waste (cei_wm011). Available at: <https://ec.europa.eu/eurostat> [Accessed: 03.11.2024]
- [13]. *** **EUROSTAT**, 2024, Packaging Waste by Waste Management Operations (env_waspac). Available at: <https://ec.europa.eu/eurostat> [Accessed: 01.11.2024]
- [14]. *** **EUROSTAT**, 2024, Area under Organic Farming (sdg_02_40). Available at: <https://ec.europa.eu/eurostat> [Accessed: 01.11.2024]
- [15]. *** **FIBL – RESEARCH INSTITUTE OF ORGANIC AGRICULTURE**, 2024, The World of Organic Agriculture: Statistics and Emerging Trends 2024, FiBL & IFOAM, Frick, Switzerland
- [16]. *** **INTERREG EUROPE**, 2024, Resource Efficiency and Circular Economy Indicators for the EU Regions, Interreg Europe Policy Learning Platform
- [17]. *** **ROMANIAN MINISTRY OF AGRICULTURE AND RURAL DEVELOPMENT (MADR)**, 2023, Statistical Report on Organic Farming in Romania (2010–2023), Bucharest