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THE IMPORTANCE OF THE CIRCULAR ECONOMY IN EUROPEAN AGRICULTURE

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Abstract: The need for greening the economy is growing both globally and in the European Union, with agriculture being a sector that occupies special attention. The strong interdependence of agriculture and the environment highlights the need to analyse the situation, perspectives, and ways to improve their relationship. The authors have singled out indicators (for the period from 2015 onwards, depending on the availability of Eurostat data) that describe the environmental challenges of European agriculture and determine future strategic directions by analysing the success achieved so far. One of the most common strategies for cutting the negative impact of each other is the circular economy. The value of the paper is reflected in the deepening and better understanding of the vision of the circular economy in agriculture. The paper will fill the theoretical gap in the literature dealing with the sustainable development of agriculture through the perspective of the circular economy and thus help agrarian policy makers in solving open problems in this sector, which, undoubtedly, has a significant impact on the natural environment. The values of agri-environmental indicators show that European agriculture is heading in the right direction from the point of view of environmental sustainability. In addition, the paper offers a socio-economic approach to analysing the challenges and benefits of applying the circular economy in agriculture. The aim is to extend the lifespan of resources by returning them back to the production process, thereby reducing waste that has harmful effects on the environment and human health. In this way, resources are used to the maximum, i.e. they are kept in the system. By using

waste in multiple production cycles, the circular economy ensures the rational use of resources, especially energy and materials, which can reduce the current import dependence on raw materials of the European Union countries.

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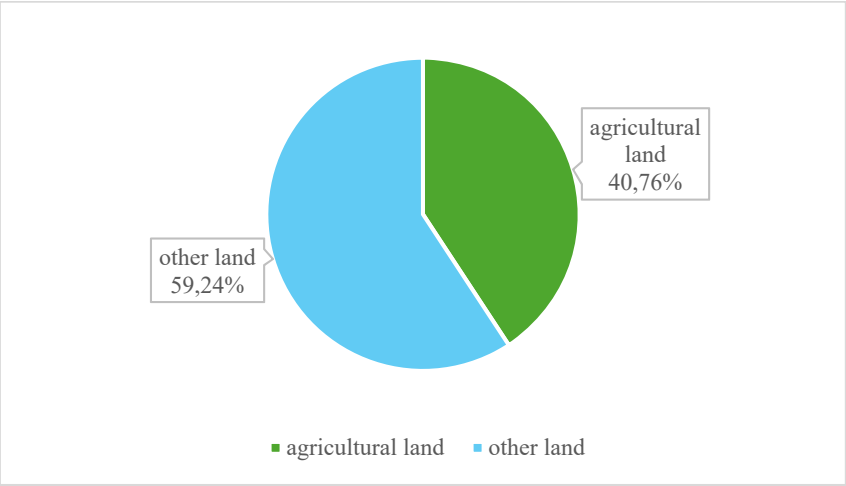
1. Introduction

Every country strives for the sustainability of agriculture, bearing in mind its socio-economic importance for all humanity. The value of agriculture for social development stems from the fact that this activity is essential for food security, rural development, employment, and regional development. The economic benefits of agriculture are particularly significant for developing countries, given its contribution to macroeconomic indicators (gross value added, employment, balance of payments).

On the other hand, the environment and agriculture are closely linked. Agriculture is the main user of natural resources and the environment, but also the leading cause of their degradation, so farmers must take care that production takes place in a way that preserves the sustainable development of this activity and society. Agricultural development depends on natural resources, often non-renewable, and if they are damaged or scarce due to harmful agricultural practices, further development of this activity is impossible. In the future, the competitiveness of agriculture will be assessed not only based on productivity and the size of exports, i.e. economic competitiveness, but also considering agri-environmental indicators that testify to its interaction with the environment (Nowak & Kasztelan, 2022).

The increased demand for food due to global population growth requires extensive agricultural practices, as agriculture is the main supplier of raw materials to the food industry. This often means increased pressure on land, as well as greater use of pesticides and water, leading to soil erosion and degradation of biodiversity. Agriculture is the main cause of environmental degradation resulting from soil use (Velasco-Muñoz et al., 2022). According to World Bank data for 2021, 40.76% of the total land in the European Union is used by agriculture (World Bank, 2024), as shown in Figure 1. Agricultural land includes arable land, as well as areas under permanent crops and pastures (World Bank, 2024). That is why agriculture is at the forefront of environmental degradation, as it is in direct contact with natural resources. Inadequate agricultural practices are the cause of many environmental costs.

Figure 1. Agricultural land in the European Union (% of land area)



Source: the authors' own presentation (in Excel) based on data from the World Bank, 2024.

The circular or non-linear economy is based on recycling, saving materials, energy, and all other resources. Ultimately, the goal is to minimize waste. The research community is increasingly committed to the ways in which agriculture can contribute to sustainable development. As agriculture is one of the leading polluters of the environment, the application of circular economy principles can be significant. The aim of this paper is to unveil and encourage the application of circular economy practices by observing the agriculture of the European Union.

The importance of the circular economy in agriculture exists due to greenhouse effects, soil degradation including soil erosion, intensive irrigation and the massive use of pesticides and fertilizers. It is a desirable alternative that tries to reconcile the increased demand for food, which will not endanger the environment, and can also ensure further economic development (Aznar-Sánchez et al., 2020). That is why it is necessary to gain insight into the state and possibilities of sustainable development of agriculture through the perspective of the circular economy. This is especially important for policymakers to ensure social welfare at the national level.

The paper first assesses the determinants of the agri-environment nexus in the European Union through the following indicators: Greenhouse gas emissions from agriculture, Areas under organic farming, Ammonia emissions from agriculture, and Final energy consumption by agriculture/forestry. Data based on the Eurostat for the period from 2015 are presented to offer an insight into the evolution of their movements over the last decade. Next, the theoretical concept of circular economy is explained, as well as the possibilities of its application in agriculture. Finally, the authors talk about the importance of applying circular solutions in this industry.

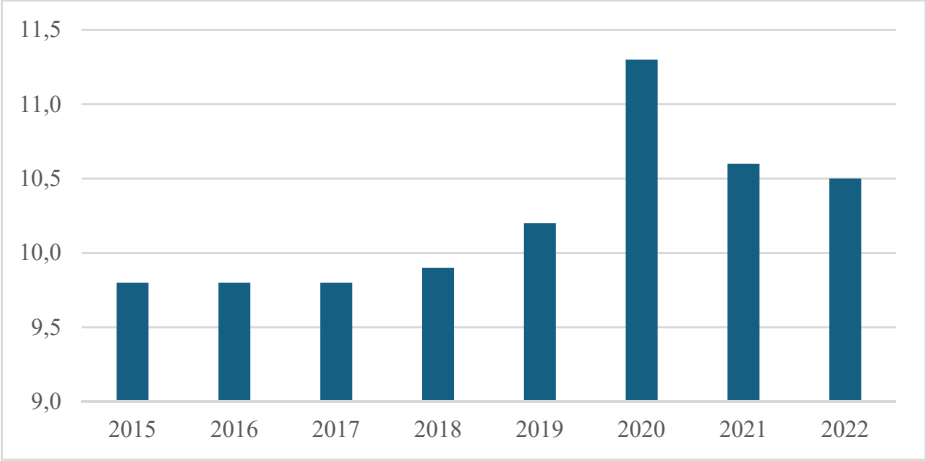
2. The Impact of European Agriculture on the Environment

The environmental impact of agriculture in this paper is evaluated based on the following factors:

- greenhouse gas emissions,
- area under organic production,
- ammonia emissions, and
- energy consumption.

The first indicator in the assessment of the relationship between agriculture and the environment is the greenhouse gas emissions that originating from agriculture. It is a phenomenon that affects climate change because it leads to global warming (Ilić et al., 2022). The percentage of impact is not high because over 10% of greenhouse effects come from agriculture. However, a negative circumstance is that there is an upward trend (Eurostat, 2024a).

Figure 2. Greenhouse gas emissions from agriculture in the European Union (in percentages)

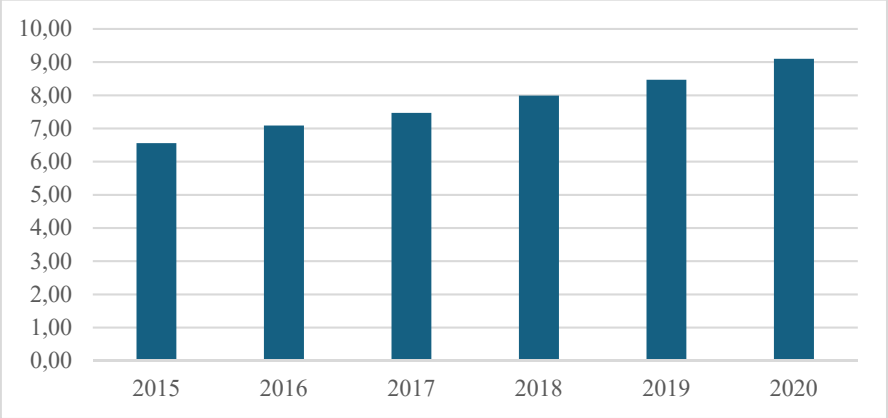


Source: the authors' own presentation (in Excel) based on data from Eurostat, 2024a.

The following agri-environmental indicator refers to the share of organic agriculture in total agricultural production (Figure 3). The European Union's Organic Agriculture Action Plan sets an ambitious target for organic farming to cover 25% of agricultural land by 2030.+ Organic farming is the easiest way to implement the principles of the circular economy and sustainable development (Marković et al., 2023). It saves resources, enables biodiversity and environmental protection, and provides producers with drastically higher incomes, especially in countries where there is a high awareness of the opportunities of circular (ecological) agriculture

from the point of view of sustainable socio-economic development (Marković, 2018). Perhaps the most important benefit of organic production is reflected in the health of the population through food safety, the exceptional nutritional value of food and the reduction of negative emissions, but the effects on employment and gross domestic product, the development and revitalization of rural areas, as well as the economic viability of small farmers should not be neglected (Rodríguez-Espinosa et al., 2023). Applying this strategy can foster long-term sustainability in every sense.

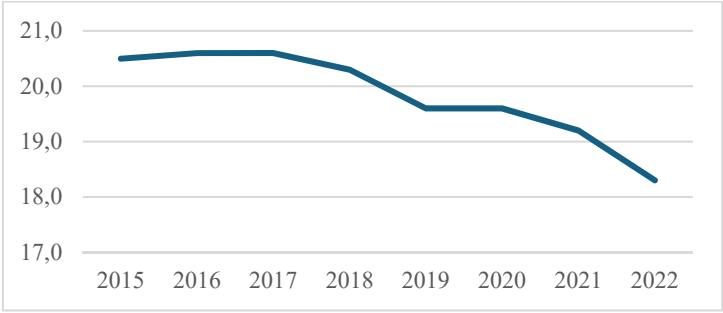
Figure 3. Area under organic farming in the European Union (in percentages)



Source: the authors' own presentation (in Excel) based on data from Eurostat, 2024b.

Ammonia emissions come almost entirely from agriculture; 91% of ammonia emissions come from agriculture (Eurostat, 2024c). That percentage has been at approximately the same level for many years (Eurostat, 2024c) because ammonia emissions from other economic activities are also decreasing. In fact, ammonia emissions from agriculture are decreasing in absolute terms (both in tonnes and kilograms per hectare), as evidenced by Figure 4.

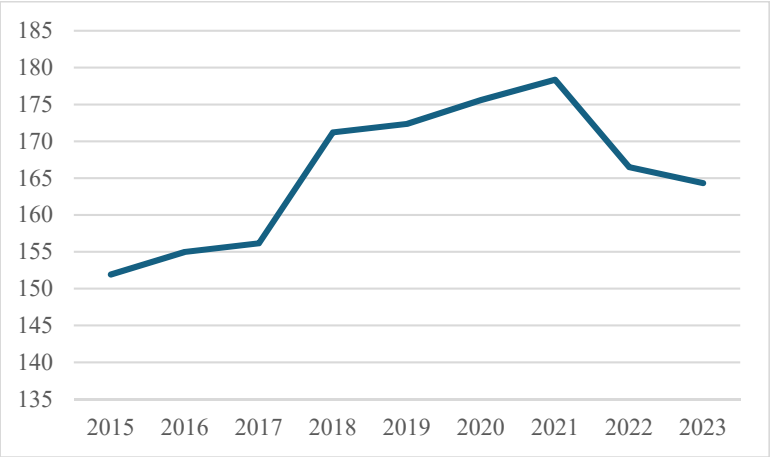
Figure 4. Ammonia emissions from agriculture in the European Union (kilograms per hectare)



Source: the authors' own presentation (in Excel) based on data from Eurostat, 2024d.

Figure 5 aims to show the final consumption of energy supplied to agriculture (including forestry). It is on a slight increase, which policy makers must pay attention to. After several years of growth, in 2022 and 2023 there will be significant savings in the energy consumed by these activities.

Figure 5. Final energy consumption by agriculture/forestry (consumption per hectare of utilised agricultural area)



Source: the authors' own presentation (in Excel) based on data from Eurostat, 2024e.

3. Circular Economy in Agriculture of the European Union as a Tool for Sustainable Development

Enormous efforts have been made in the European Union to adopt initiatives towards sustainable development. The European Green Deal, as a strategic policy for sustainability in the European Union, contains environmental requirements and solutions to slow down climate change, which also includes agriculture (Wrzaszcz & Prandecki, 2020). The protection and restoration of the natural environment is an imperative of such a policy, with the aim of transforming the European continent into a climate-neutral area by 2050 (Myskiv & Pasinovych, 2024, p. 176). In addition, the 2015 Circular Economy Action Plan was adopted at the European Union level, which stands for a new paradigm of sustainable development that will provide additional socio-economic resilience (Friant et al., 2021). This plan promotes competitiveness, investment, employment, and resource efficiency (Chiaraluce et al., 2021). It was upgraded in 2020 to align with the 2030 Agenda, which is motivated by comprehensive sustainable development. The circular economy can particularly contribute to the environmental aspect of sustainable development (Bonciu, 2023).

The full transition from a linear to a circular economy is a highly set goal at the level of the European Union as part of further sustainable development. The European Union was one of the first in the world to discover the importance of applying circular economy practices, first at the macro level through various initiatives, and then proposed concrete solutions for its application at the enterprise level (micro level). China is also a leader in the application of the circular economy, in which this concept has been intensively studied since the 1990s, so most of the publications related to the circular economy have come from this country (Duque-Acevedo et al., 2020a). Although it is a new concept, there is a rapid growth in the number of papers on the topic of circular economy and its application in many industries, including agriculture.

Since resources are limited, economics as a science exists with the aim of proposing the best use of them. Circular economy practices can help with this, especially when there is an increasing consumption of resources and the generation of waste, which undoubtedly has a harmful effect on environmental performance. The previous concept of the linear economy rests on the following relationship - "extract-produce-use-dump", so it represents an unsustainable paradigm, bearing in mind that it leads to various consequences for the environment, while, on the other hand, the circular economy is based on the constant transformation of materials, which significantly minimizes waste (Sverko Grdic et al., 2020, p. 1). From 1990 to 2020, the exploitation of natural resources more than doubled, and at the same time there was an accumulation of increasing amounts of waste (Duque-Acevedo et al., 2020, p. 1). Particularly hazardous is waste that cannot be recycled, which causes negative effects on the entire ecosystem. Recycling has still been the most common way to achieve a circular economy by returning materials to the production system (Mhatre et al., 2021). However, several circular economy strategies are distinguished in the scientific literature (Mhatre et al., 2021, pp. 14-16):

- Recycle (collection, sorting and treatment of waste and use in the production of a new product),
- Refurbish/Remanufacture (product repair),
- Reuse/Redistribute (products are reused instead of ending up as waste or recycled),
- Maintain/Prolong (use of such materials that will prolong the life of the product).

The shift from a linear to a circular economy must also be represented in agriculture, bearing in mind the specific (two-way) relationship between agriculture and the environment. It is an activity that requires more and more energy, while traditionally there is a high use of natural and other resources. On the other hand, climatic factors, soil composition and other natural resources will influence the dynamics of future agricultural development.

The circular economy in agriculture aims to increase resource efficiency, which implies the following (Rodias et al., 2021, p. 1):

- reducing the use of productive resources, especially energy and water,
- reducing the use of pesticides and synthetic fertilizers,
- the use of waste from crop and livestock production as raw materials for new production,
- recirculation of wastewater in multiple production processes.

In agriculture, there are the following circular economy strategies (Mhatre et al., 2021):

- production of organic products,
- energy production using food and raw material waste, which can affect the reduction of environmental costs and the improvement of energy efficiency (Esposito et al., 2020, p. 15),
- production of bio-fertilizers based on plant and animal waste.

Research and development activities aimed at creating innovations in this sector, focused on circularity, are essential for sustainable development. In this way, the industry sector can also develop, as circular solutions themselves often involve digitalization, eco-innovation, as well as advanced technologies. This allows for technological development that can improve the economic structure of the country. However, the prerequisites for this are: the engagement of various stakeholders, consumer responsibility, the interest of producers to radically change their habits and their way of doing business, but also the financial support of policy makers for the implementation and promotion of the concept, because the initial investments can be very high.

A circular economy based on the principles of sustainability and regeneration must be the backbone of the further development of agriculture while preserving, i.e. reduced use of resources of any kind. The justification for the application of circular solutions in agriculture is important for the environment (water, air, land), but also for the sustainable development of agriculture itself. This concept appeared from the paradigm of sustainable development with a special emphasis on responsible resource management. This is significant from the point of view of ecology, reduced pollution and climate change mitigation. The goal is to save materials and raw materials by using waste from agriculture and the food industry. It is predicted that due to climate change, the use of water will increase, therefore, circular solutions should be found for the reuse of (waste)water.

Conclusion

Increasing productivity as one of the goals of the economic development requires an increased use of pesticides. This impairs biodiversity and land quality. The circular

economy in agriculture must try to reconcile the need to increase food production and, on the other hand, the increasing environmental pollution due to the use of fossil fuels, ammonia emissions and greenhouse effects. Water conservation, biodiversity conservation and reduced land degradation can all benefit from the application of circular business models in agricultural production. The circular economy aims not only at environmental sustainability, but also at social and economic sustainability through food security, the development of rural areas (especially rural tourism), more balanced regional development, poverty reduction and the end of hunger at the macro level. Economic benefits can also be the development of the recycling industry, employment, as well as the growth of innovation for the economic development of the country. High investment in research and development and innovation can be a problem.

The essence of regenerative economy is that waste from one production cycle is used as an input in another production cycle (Rajković et al., 2020, p. 230). This leads to the conservation of natural and other resources and reduces the risk to human health. Minimizing the use of non-renewable resources and energy sources is at the core of the circular economy concept.

In the European Union, the transition to a circular economy has been facilitated due to: (i) consumer and producer awareness of the necessary changes to stop climate change (responsible consumption and production), (ii) good regulations governing this area, (iii) highly developed innovative activities thanks to the huge funds planned to support the transition to a circular economy. The European Union has developed certain indicators that assess the development of the circular economy. However, there are no specific indicators of the circular economy in agriculture, so this paper proposes the most important indicators that can be used in the future in the construction of a synthetic index to measure the degree of achieved development of the circular economy in agriculture in the European Union.

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ZNAČAJ CIRKULARNE EKONOMIJE U EVROPSKOJ POLJOPRIVREDI

Rezime: Potreba za ozelenjavanjem ekonomije raste kako globalno, tako i u Evropskoj uniji, dok poljoprivreda predstavlja sektor koji zauzima posebnu pažnju. Snažna međuzavisnost poljoprivrede i životne sredine naglašava potrebu za analizom situacije, perspektiva i načina za poboljšanje njihovog odnosa. Autori su izdvojili indikatore (za period od 2015. pa nadalje, u zavisnosti od dostupnosti podataka Evrostata) koji opisuju ekološke izazove evropske poljoprivrede i određuju buduće strateške pravce analizirajući do sada postignuti uspeh. Jedna od najčešćih strategija za smanjenje međusobnog negativnog uticaja je cirkularna ekonomija. Vrednost rada ogleda se u produbljivanju i boljem razumevanju vizije kružne ekonomije u poljoprivredi. Rad će popuniti teorijsku prazninu u literaturi koja se bavi održivim razvojem poljoprivrede kroz perspektivu cirkularne ekonomije i na taj način pomoći kreatorima agrarne politike u rešavanju otvorenih problema u ovom sektoru, koji, nesumnjivo, ima značajan uticaj na prirodno okruženje. Vrednosti poljoprivredno-ekoloških indikatora pokazuju da evropska poljoprivreda ide u pravom smeru sa stanovišta održivosti životne sredine. Pored toga, rad nudi socio-ekonomski pristup analizi izazova i koristi primene cirkularne ekonomije u poljoprivredi. Cilj je produžiti životni vek resursa vraćajući ih u proizvodni proces, čime se smanjuje otpad koji ima štetne efekte na životnu sredinu i ljudsko zdravlje. Na ovaj način, resursi se maksimalno koriste, tj. oni se čuvaju u sistemu. Korišćenjem otpada u više proizvodnih ciklusa, cirkularna ekonomija obezbeđuje racionalno korišćenje resursa, posebno energije i materijala, što može smanjiti trenutnu zavisnost od uvoza sirovina zemalja Evropske unije.

Ključne reči: cirkularna ekonomija, poljoprivreda, životna sredina, održivi razvoj, resursi, Evropska unija

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Ivana Marjanović holds a PhD in Economics and is currently a Teaching Assistant at the Faculty of Economics, University of Niš. Her research focuses on the application of quantitative methods in economics, with an emphasis on operational research and decision theory models. She has a broad range of experience in both quantitative and qualitative research, particularly in the fields of urban studies and sustainable development. Since 2022, Dr. Marjanović has been involved in the Horizon Europe project "*Twinning for Excellence in Smart and Resilient Urban Development: Advanced Data Analytics Approach*" (UR-DATA), Grant ID: 101059994. In 2024, she joined the Horizon Europe project "*CROSS-disciplinary Network for Research Excellence in Regenerative Economy Innovation Eco-Systems*" (CROSS-REIS), Grant ID: 101136834. She is also involved as a researcher in several Erasmus+ projects. She is the author of a monograph and has published over 50 scientific papers, including 13 indexed in the Web of Science (WoS), mainly in the areas of urban studies and sustainable development.

Anđela Milenković is a junior research associate at the Innovation Center of the University of Niš and a PhD student at the Faculty of Economics of the University of Niš. During all levels of her studies, she was a scholarship holder of the Ministry of Education, Science and Technological Development and the Fund for Young Talents of the Republic of Serbia. She was repeatedly awarded the best student of the year award. During her master academic studies, she accepted her professional practice in the period March-September 2022 at the Ministry of Foreign Affairs of the Republic of Serbia. Her areas of interest include business performance management, environmental and financial performance management, sustainable development economics, circular economy. She is the author of over 10 scientific papers published in journals and conference proceedings.