AGRICULTURAL WASTE IN EU AND ROMANIA WITHIN THE FRAMEWORK OF ADVANCING BIOECONOMIC GROWTH

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Abstract: *Waste management in agriculture is crucial for both resource utilization and environmental preservation. This analysis aims to explore and contrast the volume of waste generated from agricultural activities in Europe and Romania between 2014 and 2020. By delving into available data, the goal is to highlight variations in waste production and identify differences in management approaches at both EU and national levels. Special attention is given to assessing the impact on the populace by analyzing waste generation per person and its relation to agricultural land, thus grasping the challenges and trends in waste management comprehensively. This insight is pivotal in the bioeconomy landscape, where population growth drives up demand for food and agricultural products, intensifying agricultural activities and, consequently, increasing agricultural waste. The study underscores a decline in waste volume across the EU by 2020 compared to 2014, mirrored by a similar reduction of 20% in Romania. Romania's per capita waste output nearly doubles the EU average in 2020. Variations in waste volume among European countries underscore the influence of agricultural practices, technological levels, and regulatory frameworks. For instance, the Netherlands, with its intensive practices, produces significant agricultural waste, while France, with efficient practices and stringent management policies, generates less. Effective agricultural waste management demands tailored, integrated approaches suited to each country's specificities. Support for agricultural practices, resource allocation for efficient waste management technologies, and the establishment of clear standards are essential for mitigating environmental impact and fostering sustainable agricultural sector development.*

Key words*: agricultural waste, bioeconomy, management, agricultural practices*

INTRODUCTION

In order to meet the food needs of the population, agriculture is an essential pillar of economic development, but it is constantly faced with various challenges.[4] These include population growth, changes in consumer behaviour, climate fluctuations and environmental degradation.[5]

These transformations have increased the importance of environmental protection and the need for careful management of natural resources. Thus, the focus is on promoting sustainable and resilient development with the aim of minimising negative environmental impacts.

Agricultural waste refers to the leftover materials generated during the cultivation and processing of raw agricultural products. This waste consists of crop residues. Agricultural development in recent decades has led to increasing amounts of waste, residues, and by-products worldwide.[13]

Agricultural waste is an essential component of the agricultural cycle and the global ecosystem, including plant and animal residues, packaging, chemicals, with environmental, economic and social implications.[1] Moreover, they can be considered valuable resources used in different industries, such as plant waste can be transformed into fuel, animal waste into biogas or renewable energy, with implications for the economy and the promotion of sustainable development.

The transition to the bioeconomy is achieved with agricultural waste, bringing benefits to the environment and society. The bioeconomy is a new approach whereby agricultural waste is used sustainably.[3]

Potential benefits of the transition to a bio-based economy include reduced greenhouse gas emissions, reduced dependence on fossil resources, more rational management of natural resources and improved food security.[7] The generation of new jobs in both urban and rural areas can be a significant positive impact of the bioeconomy.[15] In addition, the development of new non-food markets for agriculture, such as bioenergy, in collaboration with existing food markets and through the use of alternative sources of income for farmers, can contribute significantly to the revitalization of rural areas.[10]

The prospects for positive impacts from an advanced biotechnology-based economy appear to be ample, but the challenge is to continue to achieve activities such as biomass production in parallel with achieving key sustainability goals, despite the remarkable technical potential of the bioeconomy.[11]

MATERIALS AND METHODS

The material and method used in this study focuses on investigating and comparing the volume of waste generated in the agricultural sector in both Europe and Romania. To achieve this aim, available statistical data on the amount of agricultural waste generated in the period 2014-2020 were used. The source of the data collected and processed was Eurostat.

In order to perform the analysis, a comparison of the volume of agricultural waste generated in different European countries, with a focus on the European Union (EU-27) and Romania, was carried out. Trends and variations in agricultural waste production over time were examined, and then differences in approaches to managing this waste at European and national level were identified. Quantitative analysis techniques were used to assess the impact on the population by reporting the amount of waste per person and per unit of agricultural area.

This approach provided a deeper understanding of the current situation regarding agricultural waste generation and management in Europe and Romania, thus providing a basis for identifying future directions in agricultural waste management.

RESEARCH RESULTS

In order to get an overview of the proposed topic, in the first phase of the study an analysis of the volume of waste generated at European and Romanian level in the period 2014-2020 was carried out.

The European Union (27 countries), at the level of 2020, generated 2,154 million tonnes of waste, a reduction of 14.1% compared to 2014 (2,507 million tonnes of waste). [16]

At national level, Romania generated 141 million tonnes of waste in 2020, down 20% from 2014. The highest value of waste generated was recorded in 2018, 203 million tonnes.

Table 1.

Total waste generation at EU level and Romania

Descriptions	Total waste (milions tons)		Kg waste per capita	
	European Union	**Romania**	**European Union**	**Romania**
2014	2.507	177	5.062	8.871
2016	2.531	178	5.074	9.012
2018	2.620	203	5.235	10.425
2020* EU-27	2.154	141	4.815	7.338
2020/2014 (%)	-14,1%	-20%	-4.9%	-17.3%

Source: EUROSTAT data [16] (accessed 05.03.2024)

The European Union brings together a significant variety of member countries, each with distinctive characteristics, including significant differences in population size, which also generate a variety of waste. Table 1 present an analysis of the amount of waste generated in total and per capita.

In 2020, at the EU-27 level, the volume of waste generated per capita decreased by approximately 5 percent compared to 2014. At the national level, the amount of waste generated per capita in 2020 was 2 times more higher than at the European level. The year 2018 recorded the highest amount of waste generated per capita of the analyzed period.

Agricultural waste is a major concern in the context of sustainable resource management and environmental protection. Table 2 provides analyzed statistical information regarding the amount of waste produced in the agricultural sector within both the EU-27 and Romania. In 2020, agricultural waste comprised 0.99% of the overall waste generated across Europe, amounting to 21 million tons. Over the period from 2014 to 2020, there was a notable upward trend in agricultural waste generation, registering a 14.11% increase compared to 2014 levels.

Table 2.

Total waste generation by entities of Section A-Agriculture, forestry and fishing in EU and Romania

Descriptions	EU (tons)	% from total EU waste	Romania (tons)	% from total EU waste agriculture
2014	18,710,000	0.75%	559,573	2.99%
2016	20,710,000	0.82%	507,712	2.45%
2018	20,870,000	0.80%	584,619	2.80%
2020* EU-27	21,350,000	0.99%	720,130	3.37%

Source: Own processed data EUROSTAT (accessed 05.03.2024)

In Romania, agricultural activities contributed 3.37% to the total waste output across Europe in 2020. During the period analysed, the trend was an increasing one, in 2020 the volume increased by 28.7% compared to 2014.

Comparing the volume of waste generated from the agricultural sector to the number of population, it could be seen that at EU-27 level, in 2020 the amount was 48 kg per capita, and at national level it was 37 kg per capita, the trend was increasing over time.

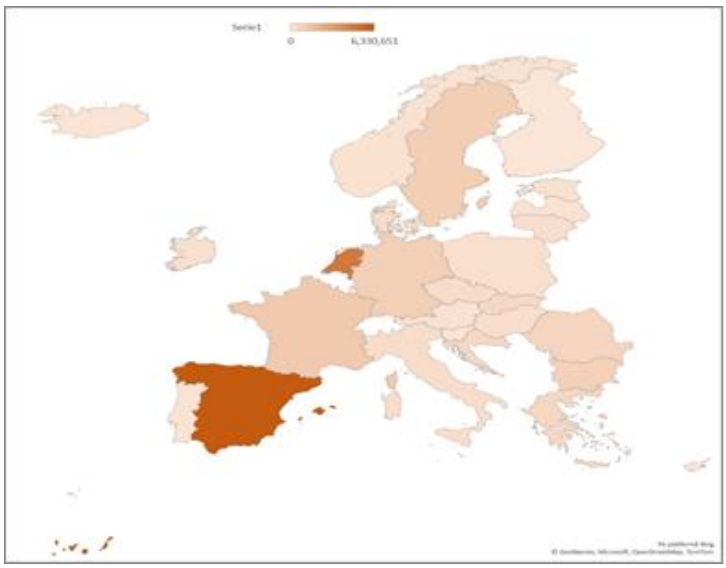

Figure 1. Total waste generation by entities of Section A-Agriculture, forestry and fishing in EU in 2020 (tons)

Source: Own processed data EUROSTAT

The Member States of the European Union are a diverse group, with significant variations in population and importance of the agricultural sector in the national economy. Therefore, an analysis was conducted on the quantity of agricultural waste generated per capita and per unit of arable land area.

The highest values of agricultural waste generated per capita, in 2020, were recorded in the Netherlands (281 kg), Estonia (147 kg), Croatia (140 kg) and Spain (134 kg). Some 60% of European countries have less than 100 kg of agricultural waste per capita. The lowest amount per capita was recorded in Italy, Poland and Portugal.

In terms of the amount of agricultural waste generated per unit area of arable land, the highest amounts of agricultural waste were recorded in the Netherlands (2,693.5 kg/ha), Malta (1,209.3 kg/ha), Croatia (459 kg/ha) and Slovakia (301.9 kg/ha). In the other Member States, the amount of waste per hectare of arable land did not exceed 250 kg. It should be noted that the higher value of this indicator in Malta and Croatia is due to the relatively small share of these countries in the total EU arable land.

The agricultural sector produces a wide range of waste. The typical waste categories for this sector have been analysed, which are of significant importance in terms of the potential for the development of the bioeconomy, in particular biomass waste. These agricultural wastes include both animal and vegetable types. Table 3 shows the volume of vegetable and animal waste in the EU-27 and Romania in the period 2014-2020.

Table 3.

Generating of animal and vegetal waste by entities of Section A-Agriculture, forestry and fishing in EU and Romania

Descriptions	**European Union (tons)**	**% from total EU Agriculture, forestry and fishing waste**	**Romania (tons)**	**% from total EU vegetal and animal waste**
2014	14,520,000	77.61%	541,332	3.73%
2016	16,250,000	78.46%	482,285	2.97%
2018	15,660,000	75.04%	559,509	3.57%
2020* EU-27	16,530,000	77.42%	699,920	4.23%

Source: Own processed data EUROSTAT [16] (accessed 05.03.2024)

At EU-27 level, the agricultural sector generated animal and vegetable waste in 2020 was 16,530 thousand tonnes of total agricultural waste being 77.42%. Compared to 2014, the volume of waste increased in 2020 by 13.84%.

An analysis of plant and animal waste in Romania revealed a rising trend, with the volume reaching 699 thousand tons in 2020, marking a 30% surge from the 2014 levels. Moreover, plant and animal waste constituted 4.23% of the total waste generated within the agricultural sector in 2020.

In 2020, the distribution of the share of animal and vegetal waste generated at the EU-27 level exhibited differentiation. Croatia and Romania recorded the highest percentages of vegetal and animal waste within the agricultural waste structure, with 98.4% and 97.2%. The highest quantities of vegetable and animal waste were recorded by Spain and the Netherlands with values of 5.6 million tonnes and 4.4 million tonnes respectively. The two European countries generated 61% of the total EU-wide biomass of crop and animal waste.

Spain leads the European Union in agricultural waste production, largely due to the significant amount of animal excrement, urine, and litter generated domestically. These organic materials form a considerable portion of agricultural waste and play a significant role in Spain's overall output in this sector.[5]

Cyprus, Luxembourg and Malta generated the lowest amounts of vegetable and animal waste below 9,000 tonnes.

In terms of the volume of agricultural crop and animal waste per capita, in 2020, in the EU-27 it was 37 kg. The highest values were recorded in the Netherlands, 253 kg per capita, Croatia 137 kg per capita, Bulgaria and Estonia. Romania recorded a value of 36 kg per capita. More than 60% of European countries record a quantity of vegetal and animal waste per capita below the European average.

The study further aims to show the complex relationship between population size, arable land and the amount of crop and animal waste generated at EU-27 level in 2020 (Figure 2).

The link between the three indicators plays a key role in the bioeconomy. Therefore, a greater population within a specific region or member state drives up the demand for food and agricultural goods, potentially resulting in more intensive agricultural practices and consequently higher levels of agricultural waste generation. Simultaneously, a larger expanse of arable land can augment production capabilities, further contributing to the generation of agricultural waste.

The amount of agricultural waste generated can also be influenced by the agricultural practices used, the technological level of agricultural production and waste management regulations.

Figure 2 shows some aspects related to the subject matter as highlighted.

- The Netherlands, despite having a small area of arable land and a relatively small population compared to other European countries, generates a large volume of agricultural waste. This may be largely due to intensive agricultural and horticultural practices, which result in high agricultural production, but also significant amounts of waste associated with this activity. [9]

- France, even though it has a large area of arable land and a high population, generates less agricultural waste. This is largely due to the advanced and efficient agricultural practices used, which result in a more rational use of resources and more efficient management of agricultural waste. In comparison to other European states, France implements strict regulations regarding agricultural waste management, thus contributing to the reduction of waste volume generated.[12]

- Spain generates a high volume of agricultural waste, holding a large arable land area as well as a sizable population.This can be attributed to the intensity of agricultural activity in the country, which involves a wide range of crops and farming practices.[6, 8]

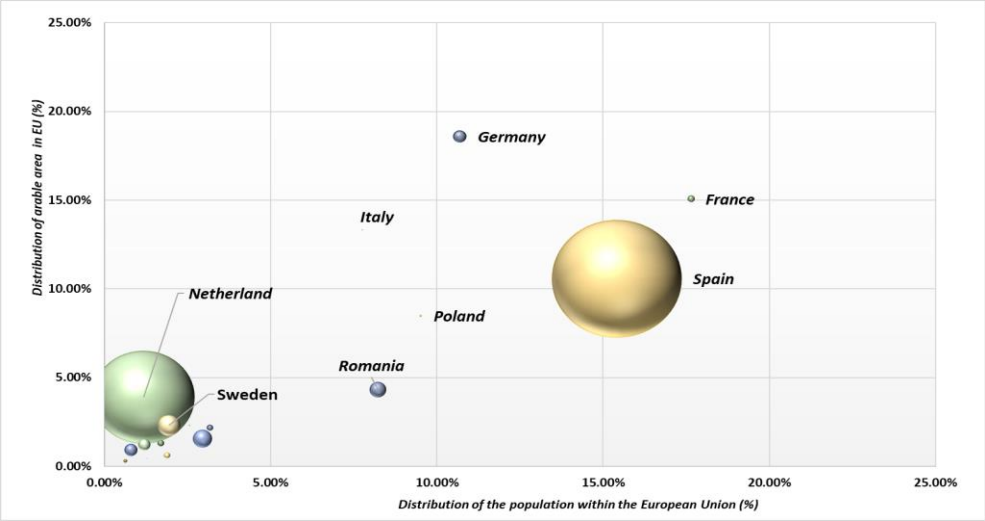

Figure 2. The intensity of the amount of waste generated in the agricultural sector at the EU-27 level in relation to the arable surface and population

Source: Own processed data EUROSTAT (accessed 05.03.2024)

A thorough understanding of the relationships between population size, arable land expansion and agricultural waste generation is crucial for promoting a sustainable bioeconomy and more efficient use of resources in agriculture and other related sectors.

Eurostat identifies several categories of treatment and disposal of vegetable waste, such as landfilling, incineration and energy recovery or recycling and landfilling.

In 2020, at EU-27 level, 46.53 million tonnes of vegetable waste were treated. Countries with high percentages of total treated biowaste include the Netherlands (20.3%), Germany (26.03%), France (15.5%) and Belgium (11.05%). At EU-27 level, energy recovery and recycling and landfilling had the highest percentages, respectively 3.83% and 94%.

In Romania, 1.12 million tonnes of treated vegetable waste were recorded in 2020, representing 2.39% of total treated vegetable waste at European level. Of this, 24.2% was disposed of in landfill or other methods, 7.45% was subject to energy recovery and the remaining 68.3% was recycled or landfilled.

For animal waste (feces, urine and manure), 10.16 million tonnes were recorded in the EU-27 in 2020, of which the highest percentages were achieved through energy recovery and recycling, with 8.3% and 86.8% respectively.

A significant share of total treated animal waste was recorded in countries such as the Netherlands (37.17%), France (10.38%) and Germany (6.57%).

Romania contributed 0.14% of the total treated animal waste, with 13,998 tonnes, which was disposed of in landfills or by other methods.

Proper treatment of plant and animal waste is essential to protect the environment, reduce climate impact, promote the circular economy and protect public health.[14] Effectively managing agricultural waste is vital for preserving the environment and mitigating its adverse effects on natural resources and human well-being. It's essential not just to handle and eliminate current waste but also to curb its overproduction through the adoption of sustainable agricultural methods and technologies.[2] Investments in infrastructure and appropriate technologies for the responsible management of this waste are essential.

CONCLUSIONS

During 2014-2020, waste generation in both the EU-27 and Romania changed. The EU-27 experienced an overall reduction in waste volume due to improved waste management and sustainability practices. Conversely, Romania saw a decline in waste generated per capita, although it remains notably higher than the EU average. Also, the concern for agricultural waste is evident, an increase in its volume in the agricultural sector over time, highlights the importance of sustainable resource management and environmental protection.

The agricultural sector is a significant source of waste in Europe, and the general trend over the period under review has been an increase in its volume. This increase raises concerns about the management and impact of agricultural waste on the environment and the economy. Detailed analysis of the geographical distribution of agricultural waste, as well as the amount per capita and per unit of arable area, highlights the significant variations between EU Member States and the importance of the agricultural sector in each country. The focus on waste categories, in particular biomass waste, also highlights their potential in the development of the bioeconomy.

The agricultural sector in the EU-27 and Romania generates a significant amount of animal and vegetable waste, and the general trend over the period under review is for its volume to increase. The percentage distribution of agricultural waste within the EU-27

reflects significant variations between Member States, with some countries such as Spain and the Netherlands being the main generators. The significant differences in the amount of agricultural waste generated per capita between countries underline the importance of understanding the complex relationships between population, agricultural land area, and waste management to promote a sustainable bioeconomy and efficient resource utilization in agriculture and related industries.

Responsible management of crop and animal waste is crucial for protecting the environment, reducing climate impact, promoting the circular economy and protecting public health. Analysis of data at EU-27 level and in Romania highlights the diversity of ways to deal with these wastes, such as recycling, energy recovery and landfilling. It can be seen that Member States adopt different strategies in waste management and investments in infrastructure and appropriate technologies are essential to ensure efficient and sustainable management of plant and animal waste.

Animal and vegetal waste is a major concern and investment in infrastructure and appropriate technologies is essential to ensure its efficient and sustainable management. Promoting a sustainable bio-economy and a more efficient use of resources in agriculture and related sectors is crucial for environmental protection and public health.

In conclusion, responsible waste management must remain a priority and the implementation of appropriate strategies and policies is essential to ensure a healthy environment and a sustainable economy in our future.

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