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COMPARATIVE ANALYSIS OF CIRCULAR ECONOMY INDICATORS ACROSS EUROPEAN COUNTRIES

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Abstract
Circular economy is a development strategy that is based on the principle of reduction, reuse and recycling, also called the 3-R principle aiming to create a closed-loop system where the outputs of one process become the inputs for another, fostering efficiency and resilience. The development of the circular economy by production sectors involves implementation of sustainable practices working towards minimizing waste, optimizing resource efficiency by use of by-products and regenerate natural systems. In agrofood sector, this can be practically translated in various strategies such as recycling organic waste to create fertilisers for soil enrichment, employing precision farming techniques to minimize input use while maximizing yields, adopting agroecology practices to enhance biodiversity and soil health, and promoting local food systems to reduce transportation emissions. In this context, the purpose of the paper is to analyse the dynamics of circular economy indicators with impact on the agrifood sector at the level of the EU countries, thus comparing the diversity of circular economy implementation levels.

Keywords: dynamics, circular economy, measurable indicators, EU countries.

1. INTRODUCTION

The concept of circular economy is increasingly promoted in different sectors, and international organizations such as: FAO, UNICEF and WHO show great interest in this type of economic model. As a result, research on the application of circular economy principles in agriculture has become increasingly numerous and relevant (Craparo et al., 2023).

According to the study by Ali & Ali, 2023, the concept of circular economy in agriculture started gaining notoriety after 2015, when it gradually started to receive significant attention from the scientific community, experiencing an exponential increase in research publications and citations. Of the top 10 editorial countries on the circular economy and agriculture, 6 countries belong to the European Union.

The circular economy emerged as a regenerative concept that minimizes emissions, based on renewable energy and waste elimination based on closed-loop system design and reuse of materials and resources. As a result, the agricultural economy, as an integral branch of the global economy covering the entire supply chain of agricultural production including cultivation, processing, distribution and consumption, is of great importance to the realization of a circular economy (Xia & Ruan, 2020).

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Implementing circular economy practices in resource-intensive agricultural systems is critical to reducing the environmental ramifications of current linear systems. As a segment of the circular economy, the bioeconomy facilitates the production of renewable biological resources (i.e. biomass) that are transformed into nutrients, bioproducts and bioenergy. Also, the use of recycled agro-industrial wastewater in agricultural activities (e.g. irrigation) can further stimulate the circularity of biosystems (Rodias et al., 2020).

The circular economy establishes the efficient use of resources based on: reduction, reuse, recycling as a principle and low consumption, low emissions and high efficiency as basic characteristics. Thus, the circular economy plays an important role in achieving scientific development and conservation-oriented society (Zhao, 2013).

Respecting the principles of the 3Rs and developing agriculture based on them has become one of the most important priorities for the development of the economy in many countries. This imposes greater demands on optimizing the agricultural technical innovation system, exploring new ways, and improving the agricultural model that depends on resource consumption (Long & Yao, 2013).

According to Borrelli, 2018, to create a circular economy it is necessary to assume its principles in all stages of the value chain, which inevitably requires a revision according to the specifics of the sector in mind. Agriculture is not exempt from this commitment, the need to reflect on the way in which the principles of the circular economy are integrated into the activity of agri-food enterprises is increasingly being discussed.

On the other hand, Hanumante et al., 2019 argues that the circular economy is modeled as an industry that processes used industrial goods. They are used together with goods produced using virgin raw materials. At the same time, the authors believe that the different delays and circulation rates parameterize 90 different ways of implementing the circular economy. And these are implemented for nine levels of increased resource consumption by humans, supplemented by population growth. Also, system collapse due to scarcity of ecosystem resources occurs earlier as consumption levels increase.

The core of circular agriculture is promoting the circular use of agricultural resources. According to Jun & Xiang, (2011), the circular economy is the way to achieve harmonious development between the economy and the environment.

The implementation of circular economy principles is one of the central objectives of several governments that want a transition to sustainable development. And the circular economy in agriculture deals with the production of basic agricultural products, using resources efficiently and avoiding the unnecessary generation of waste and carbon emissions. Research by Fan et al., 2018, shows that disruptions in the production and supply of critical agricultural products can have negative repercussions for businesses and consumers in the food supply chain. Research results have shown that in recent decades, disruptions caused by natural disasters such as hurricanes, storms and floods have greatly affected social communities and industrial sectors. And the authors believe that supply chain risk approaches contribute key elements to addressing the impact of natural disasters on the implementation of the circular economy in agriculture, helping to prevent the collapse of food production and supply.

On the other hand, agriculture is one of the sectors that contribute heavily to the planet's greenhouse gas emissions. In this sense, circular economy practices can be advantageous when using bioenergy in the agro-industrial sector. Although only a percentage of approx. 9% of the world economy is circular, global initiatives act to increase this percentage. In contrast to the linear economy (take-

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make-use-dispose), the circular economy (growth-make-use-restoration) aims to influence material and energy flows to increase environmental benefits and avoid costs (Barros et al. , 2020).
Although at the level of EU countries, the adoption of circular economy principles became a trend much earlier than other states, they still face challenges in their adoption (Tleuken et al., 2022).
In the Netherlands, although it is not yet very clear how the circular economy will develop, it is known that the implementation of circular economy principles at country level is a priority. The Dutch government expressed as a priority the development of measures to support the development of the circular economy in the Netherlands until 2050. Following this, the Dutch Ministry of Agriculture, Nature and Food Quality established a vision for circular agriculture (Dagevos & Lauwere, 2021).
Also, at the level of Spain in the last decades, the ecosystems have shown several negative influences on the environment, these influences being caused by human activities, including the disposal of plastic waste. This situation led the EU to introduce a new policy based on the circular economy. The results of the study by Castillo-Díaz et al., 2021, show that the volume of plastic waste from intensive agriculture in Almeria is constantly increasing (48,948.2 tons in 2020/21) and it is suggested that the current management system does not meet the needs of the sector.

2. MATERIALS AND METHODS

This research is based on circular economy indicators – production and consumption subcategory, the data series being provided by the National Institute of Statistics (INS) and Eurostat. To carry out the study, the following indicators were analyzed: consumption of raw materials, productivity of resources, generation of waste per capita, generation of municipal waste per capita, generation of packaging waste per capita, generation of plastic waste per capita per inhabitant and food waste. The research method used was the analysis of quantitative and qualitative data, as well as the comparative analysis between the values of the indicators of the circular economy at the level of the EU states.

3. RESULTS AND DISCUSSIONS

The consumption of raw materials is an indicator that quantifies the demand for material extraction determined by the consumption and investments made by households, governments and businesses in the EU. This indicator is a measure of material footprints. At the level of the EU countries, the consumption of raw materials presented, mainly, a positive dynamic. The biggest increases in consumption were recorded by Denmark (+48.35%), followed by Romania (+30.56%) and Slovenia (+28.99%). On the other hand, among the countries that recorded the biggest decreases in the consumption of raw materials are Malta (-30.25%), the Netherlands (-21.65%) and Austria (-13.16%) (Table 1).
In the last analyzed year, namely the year 2022, the highest consumption of raw materials was recorded by Finland (45.961 tons/capita) and Denmark (34.393 tons/capita). Romania is also among the top three raw material consuming countries with a consumption of 30.477 tons per capita in 2022 (Table 1).
At the European level, the dynamics of the consumption of raw materials at the European level varied between 14.222 in 2020 and 14.921 in 2022 (Figure 1).
Regarding the indicator that measures the productivity of resources by relating the gross domestic product (GDP) to the domestic consumption of materials, at the level of the EU countries during the analyzed period, significant increases in the productivity of resources were highlighted in some

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states such as Iceland (+56.67%), Ireland (+40.36%) and Hungary (+30.75%). At the opposite pole, among the countries that recorded decreases in resource productivity are: Italy (-7.51%), Lithuania (-5.49%) and Sweden (-3.95%). Romania is the country that recorded the largest reduction (-9.56%) of resource productivity in the analyzed period, from 0.4224 euro/kg in 2018 to 0.382 euro/kg in 2022.

Table 1. Dynamics of consumption of raw materials at the level of EU countries in the period 2018-2022 -tons/capita-

Country	2018	2019	2020	2021	2022	2022/2018
Finland	47.737	45.693	45.487	46.145	45.961	-3.72%
Denmark	23.184	24.237	25.582	26.845	34.393	48.35%
Romania	23.343	27.877	30.401	31.451	30.477	30.56%
Sweden	25.776	26.385	24.79	27.857	28.533	10.70%
Estonia	29.662	27.732	28.886	29.829	27.372	-7.72%
Luxembourg	28.082	27.183	24.703	31.083	26.961	-3.99%
Bulgaria	21.199	21.702	20.68	22.594	26.168	23.44%
Cyprus	22.995	24.57	23.053	25.161	23.963	4.21%
Lithuania	20.194	20.562	21.863	23.079	22.61	11.96%
Slovenia	16.511	16.163	16.908	18.673	21.297	28.99%
Austria	23.927	23.473	20.222	21.488	20.778	-13.16%
Latvia	17.518	17.771	18.006	19.341	20.034	14.36%
Poland	18.988	18.504	18.004	18.408	19.941	5.02%
Czechia	17.578	17.289	16.136	17.942	18.455	4.99%
Portugal	16.728	17.227	15.615	16.945	16.887	0.95%
Belgium	14.92	12.822	12.985	12.799	15.879	6.43%
Germany	16.101	15.852	15.069	16.003	15.66	-2.74%
Switzerland	17.301	17.489	16.537	15.861	15.239	-11.92%
Croatia	13.681	14.354	13.085	13.866	15.229	11.31%
Hungary	14.963	15.971	14.632	14.896	14.944	-0.13%
Greece	12.12	12.301	11.439	12.088	13.87	14.44%
France	13.67	13.786	12.699	13.978	13.228	-3.23%
Italy	11.78	11.051	10.228	11.989	12.781	8.50%
Slovakia	14.625	13.832	13.282	13.595	12.77	-12.68%
Ireland	12.228	13.432	10.188	10.717	12.103	-1.02%
Spain	11.016	10.28	10.04	10.35	9.797	-11.07%
Netherlands	8.63	8.589	8.163	7.484	6.762	-21.65%
Malta	9.531	12.316	13.548	12.371	6.648	-30.25%

Source: Eurostat, accessed on April 2024

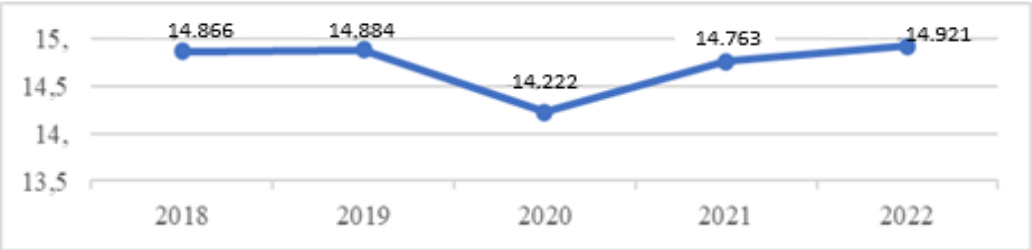

Figure 1. Dynamics of consumption of raw materials at EU-27 level (2020) in the period 2018-2022 - tons/capita-

Source: processing based on data provided by Eurostat, accessed on April 2024

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In 2022, the first three countries that recorded the highest resource productivity at European level were: Switzerland (7.8783 euros/kg), the Netherlands (4.5753 euros/kg) and Luxembourg (4.3185 euros/kg). At the other extreme, Bulgaria (0.3361 euro/kg), Romania (0.382 euro/kg) and Estonia (0.6886 euro/kg) are ranked with the lowest resource productivity values (Table 2).

Table 2. Dynamics of resource productivity at the level of EU countries in the period 2018-2022 -euro/kg-

Country	2018	2019	2020	2021	2022	2022/2018
Switzerland	7.1409	7.1293	7.2348	7.6528	7.8783	10.33%
Netherlands	3.8678	4.0546	4.2887	4.6529	4.5753	18.29%
Luxembourg	4.1622	4.1913	4.1966	4.0377	4.3185	3.76%
Ireland	2.7732	2.8666	3.2756	3.6825	3.8925	40.36%
Italy	3.5269	3.4612	3.4284	3.331	3.2622	-7.51%
France	2.9831	2.9516	3.0382	2.9293	3.1218	4.65%
Belgium	3.0398	2.9829	3.0819	3.3316	3.0552	0.51%
Germany	2.5897	2.7082	2.6876	2.7016	2.8284	9.22%
Spain	2.627	2.7359	2.4586	2.5243	2.7949	6.39%
Malta	1.9526	2.1943	1.8368	2.1126	2.466	26.29%
Austria	2.361	2.3655	2.1904	2.2252	2.3998	1.64%
Denmark	2.1214	2.1309	2.1363	2.1903	2.0584	-2.97%
Sweden	1.938	1.883	1.9267	1.8306	1.8615	-3.95%
Greece	1.3798	1.4798	1.5351	1.6316	1.5401	11.62%
Slovakia	1.1894	1.3387	1.3376	1.3862	1.485	24.85%
Slovenia	1.4702	1.6074	1.5808	1.5821	1.4843	0.96%
Cyprus	1.3594	1.3319	1.3256	1.3078	1.4114	3.83%
Portugal	1.1561	1.1747	1.2015	1.183	1.2575	8.77%
Iceland	0.78	1.0051	1.071	1.3963	1.222	56.67%
Croatia	1.1688	1.1712	1.0542	1.1839	1.1947	2.22%
Czechia	1.1095	1.1328	1.1559	1.1417	1.1404	2.79%
Hungary	0.8192	0.8274	0.9138	0.9875	1.0711	30.75%
Finland	0.8725	0.9279	0.9013	0.9431	0.9672	10.85%
Latvia	0.9647	0.9855	0.9613	0.9292	0.9348	-3.10%
Poland	0.7027	0.7711	0.7649	0.7992	0.7959	13.26%
Lithuania	0.8374	0.8202	0.7753	0.7922	0.7914	-5.49%
Estonia	0.5598	0.6468	0.6687	0.6974	0.6886	23.01%
Romania	0.4224	0.3684	0.3383	0.352	0.382	-9.56%
Bulgaria	0.3488	0.3601	0.3514	0.3416	0.3361	-3.64%
Norway	2.6275	2.6686	2.8642	3.1312	-	-

Source: Eurostat, accessed on April 2024

At the EU-27 level, resource productivity showed a positive dynamic, with small variations, in the period 2018-2022, showing an increase of 3.96%, from 2.0451 euros/kg in 2018 to 2.1261 euros /kg in 2022 (Figure 2).

The next indicator analyzed, waste generation per capita is an indicator that is calculated by relating the total waste generated in a country, including major mineral waste, to the country's average. At the level of the EU-27 countries, the countries that generated the largest amounts of waste per capita in 2020 are: Finland (20.993 kg/capita), Bulgaria (16.785 kg/capita) and Sweden (14.664 kg /head

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is inhabitant). Romania ranks eighth with an amount of waste generated per capita of 7.338 kg, after Austria (7.338 kg/capita) and Estonia (12.163 kg/capita) (Table 3).

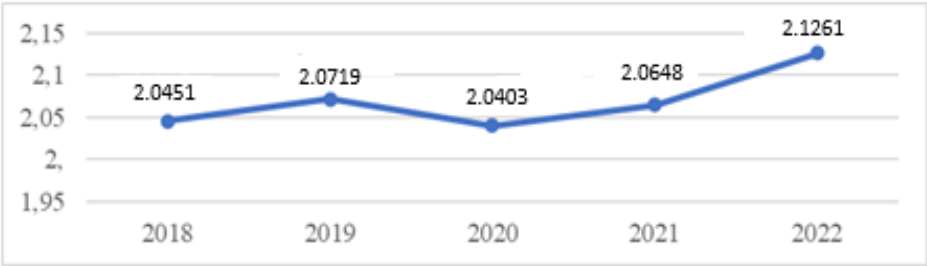

Figure 2. Productivity of resources at EU-27 level (2020) in the period 2018-2022 -euro/kg-
Source: processing based on data provided by Eurostat, accessed on April 2024

Table 3. Dynamics of waste generation per capita at the level of EU-27 countries (2020) in the period 2012-2020 -kg/capita-

Country	2012	2014	2016	2018	2020	2020/2012
Finland	16.961	17.572	22.359	23.253	20.993	23,77%
Bulgaria	22.072	24.872	16.907	18.470	16.785	-23,95%
Sweden	16.420	17.226	14.272	13.628	14.664	-10,69%
Luxembourg	15.816	12.713	17.217	14.828	14.618	-7,57%
Liechtenstein	12.727	15.278	13.325	11.448	13.951	9,62%
Estonia	16.627	16.587	18.451	17.539	12.163	-26,85%
Austria	5.699	6.537	7.008	7.428	7.728	35,60%
Romania	12.432	8.871	9.012	10.425	7.338	-40,97%
Netherlands	7.233	7.848	8.281	8.429	7.175	-0,80%
Malta	3.467	3.849	4.287	5.173	6.847	97,49%
Belgium	4.847	5.171	5.573	5.967	5.899	21,70%
Germany	4.576	4.785	4.858	4.891	4.824	5,42%
France	5.264	4.893	4.836	5.112	4.593	-12,75%
Poland	4.266	4.714	4.793	4.621	4.492	5,30%
Czechia	2.205	2.223	2.402	3.560	3.598	63,17%
Slovenia	2.210	2.273	2.661	3.964	3.576	61,81%
Denmark	2.989	3.687	3.663	3.702	3.453	15,52%
Ireland	2.764	3.256	3.207	2.874	3.248	17,51%
Italy	2.594	2.597	2.702	2.855	2.942	13,42%
Iceland	1.651	2.490	3.182	3.667	2.895	75,35%
Greece	6.549	6.404	6.712	4.215	2.651	-59,52%
Norway	2.136	2.066	2.127	2.662	2.610	22,19%
Cyprus	2.171	2.321	2.897	2.646	2.491	14,74%
Lithuania	1.901	2.114	2.327	2.527	2.396	26,04%
Slovakia	1.558	1.636	1.953	2.277	2.340	50,19%
Spain	2.535	2.378	2.774	2.945	2.230	-12,03%
Hungary	1.644	1.688	1.624	1.879	1.759	7,00%
Portugal	1.271	1.381	1.427	1.546	1.612	26,83%
Latvia	1.135	1.315	975	920	1.501	32,25%
Croatia	846	879	1.286	1.355	1.483	75,30%

Source: Eurostat, accessed on April 2024

On the other hand, the Czech Republic and Slovenia and Slovakia stand out for the most significant increases in the amount of waste generated per capita in the analyzed reference period 2012-2020,

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respectively 63.17%, 61.81% and 50.19% . And at the opposite pole, Greece (-59.52%), Romania (-40.97%) and Estonia (-26.85%) stand out with the most significant reductions in quantity (Table 3). As for the amount of waste per capita generated in the EU, it registered an upward trend during the analyzed period (+27%), from 3,791 to 4,815 kg/capita (Figure 3).

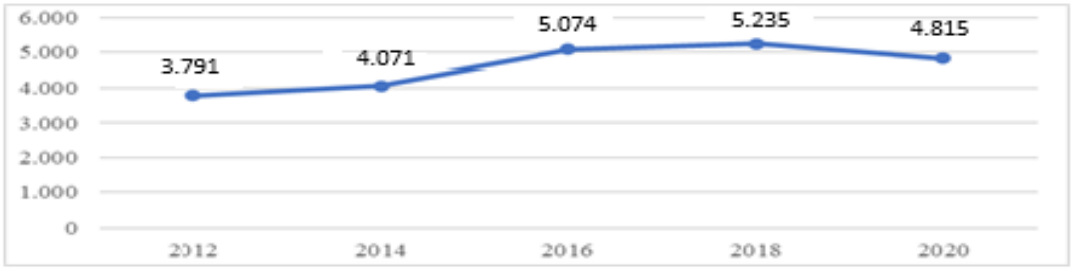

Figure 3. Dynamics of waste generation per capita at EU-27 level (2020) -kg/capita-
Source: processing based on data provided by Eurostat accessed on April 2024

Table 4. Dynamics of packaging waste generation per capita at the level of EU-27 countries (2020) in the period 2017-2021 -kg/capita-

Country	2017	2018	2019	2020	2021	2021/2017
Belgium	156.55	157.51	160.62	167.28	170.75	9.07%
Bulgaria	64.05	70.82	79.49	-	-	-
Czechia	115.03	122	125.04	124.21	136.79	18.92%
Denmark	168.29	173.1	169.11	179.34		
Germany	226.52	227.49	227.55	225.79	236.69	4.49%
Estonia	175.46	158.15	157.64	154.74	149.96	-14.53%
Ireland	215.98	208.06	227.98	224.45	246.14	13.96%
Greece	73.13	75.91	81.1	-	-	-
Spain	161.7	161.22	170.04	168.21	182.68	12.97%
France	193.08	195.49	187.01	187.6	197.72	2.40%
Croatia	63.85	67.75	74.03	66.03	73.84	15.65%
Italy	217.35	211.2	215.64	208.77	229.9	5.77%
Cyprus	89.94	86.73	92.31	91.68	85.31	-5.15%
Latvia	122.17	133.54	136.74	142.81	153.9	25.97%
Lithuania	127.72	126.58	134.41	136.79	-	-
Luxembourg	225.15	224.04	217.22	205.22	214.24	-4.85%
Hungary	128.82	138.35	142.79	154.61	-	-
Malta	146.76	146.65	153.7	139.81	150.43	2.50%
Netherlands	183.17	165.05	170.42	173.55	171.52	-6.36%
Austria	156.52	159.9	161.89	157.34	164.3	4.97%
Poland	153.98	143.98	172.19	-	-	-100.00%
Portugal	166.01	173.47	172.22	175.07	176.54	6.34%
Romania	71.92	80.47	103.81	116.38	-	-
Slovenia	113.29	114.81	117.44	118.16	133.99	18.27%
Slovakia	95.15	102.2	104.77	103.67		-100.00%
Finland	135	127.93	131.44	157.66	158.74	17.59%
Sweden	130.75	133.04	134.31	132.06	156.83	19.95%
Iceland	150.4	146.79	149.05	130.61	147.77	-1.75%
Liechtenstein	169.88	174.66	178.39	195.49	192.04	13.04%
Norway	163.05	161.11	165.51	173.45	-	-

Source: Eurostat, accessed on April 2024

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From the analysis of the amount of packaging waste per capita at the EU-27 level (2020), in the period 2017-2021 an increase of approx. 22%, from 173.84 in 2017 to 188.69 kg/capita in 2021 (Figure 4).

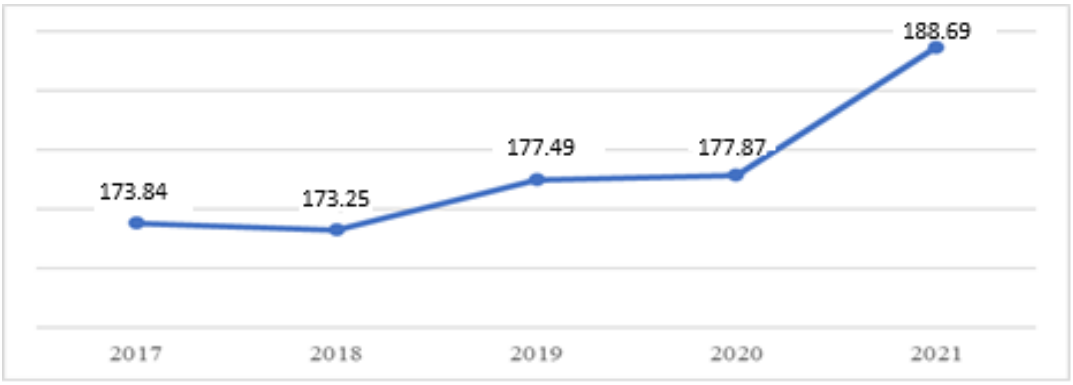

Figure 4. Dynamics of packaging waste generation per capita at EU-27 level (2020) -kg/capita-
Source: processing based on data provided by Eurostat accessed on April 2024

Also, the amount of plastic packaging waste per capita in the EU-27 countries (2020) showed an increasing trend (+26.21%), reaching 35.92 kg/capita in 2021, from 32.64 kg/capita in 2017 (Figure 5).

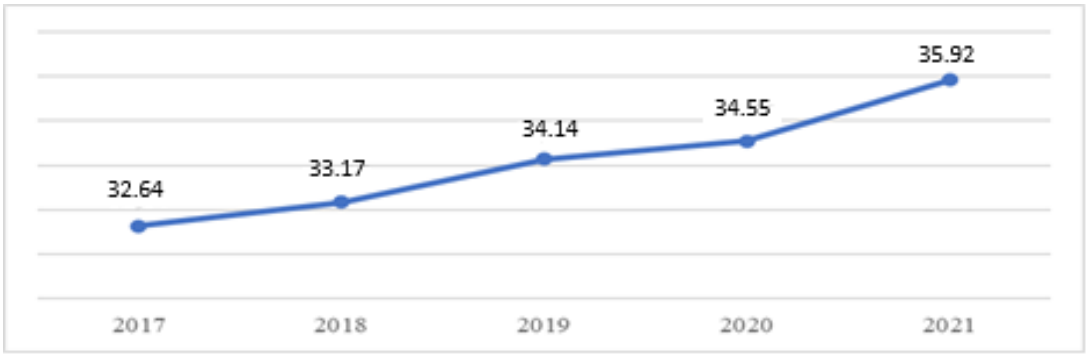

Figure 5. Dynamics of plastic packaging waste generation per capita at EU-27 level (2020) -kg/capita-
Source: processing based on data provided by Eurostat accessed on April 2024

From the comparative analysis at the level of EU countries, in 2021 Ireland was the country that ranked at the top of the ranking with the highest volume of plastic waste generated per inhabitant, respectively 74.07 kg/capita, registering an increasing trend (+26.88%) in the period 2017-2021. The biggest increase in the amount of plastic waste was recorded in Sweden (+63.44%). And the country with the lowest amount of plastic waste generated per capita was Croatia with 17.91 kg/capita in 2021. At the same time, a significant decrease in the amount of plastic waste per capita was observed in Estonia during the analyzed period (-24.66%), from 49.95 to 37.63 kg/capita.
Regarding the amount of plastic packaging waste generated per capita in Romania, it has registered an upward trend (+36%) in the last four years in which Eurostat data were provided, from 18.4 in 2017 to 24.95 kg/capita in 2020 (Table 5).

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Table no. 5. Dynamics of waste generation from plastic packaging per capita at the level of EU-27 countries (2020) in the period 2018-2022 -kg/capita-

Country	2017	2018	2019	2020	2021	2021/2017
Ireland	58.38	54.24	64.67	61.52	74.07	26.88%
Iceland	46.74	47.55	48.51	39.42	44.55	-4.69%
Portugal	38.86	40.31	40.54	40.34	41.32	6.33%
Germany	38.53	39.03	39.11	39.71	41.09	6.64%
Sweden	23.93	24.17	23.9	24.03	39.11	63.44%
Italy	37.52	37.93	38.75	37.16	38.4	2.35%
Estonia	49.95	41.9	43.31	40.32	37.63	-24.66%
Spain	34.53	35.37	35.75	36	37.34	8.14%
France	34.8	35.09	35.47	35.69	36.79	5.72%
Luxembourg	46.39	42.61	42.3	39.08	35.8	-22.83%
Austria	34.36	34.16	33.31	33.55	33.36	-2.91%
Belgium	30.36	30.4	30.57	32	32.02	5.47%
Netherlands	29.89	30.35	30.15	31.76	31.13	4.15%
Malta	28.41	31.8	31.77	27.43	30.88	8.69%
Finland	23.66	24.52	24.22	28.41	29.94	26.54%
Czechia	23.59	25.16	24.76	24.72	27.1	14.88%
Slovenia	24.28	23.81	23.88	23.68	26.22	7.99%
Latvia	20.31	22.63	22.22	24.58	25.53	25.70%
Liechtenstein	20.6	21.11	21.64	23.21	23.17	12.48%
Cyprus	20.47	19.97	20.63	20.28	20.85	1.86%
Croatia	14.67	15.73	16.76	16.27	17.91	22.09%
Bulgaria	16.95	18.7	23.36	-	-	-
Denmark	34.81	42.88	39.8	39.27	-	-
Greece	17.5	18.83	20.76	-	-	-
Lithuania	25.42	27.08	29.83	30.81	-	-
Hungary	32.24	34.84	35.02	47.45	-	-
Poland	27.42	25.94	34.19	-	-	-
Romania	18.4	20.1	24.87	24.95	-	-
Slovakia	22.83	24.22	24.69	23.49	-	-
Norway	41.81	41.74	44.86	46.12	-	-

Source: Eurostat, accessed on April 2024

Regarding the amount of municipal waste per capita, at the level of the EU member states, Denmark is the country that occupies the first place, generating an amount of 787 kg/capita in 2022, with approx. 97% more than the amount generated in 2018, i.e. 814 kg/capita. At the other extreme, with the lowest amount generated per capita is Romania with 301 kg/capita in 2022, approx. 111% more than the amount generated in 2018, respectively 272 kg/capita (Table 6).

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Table 6. Dynamics of municipal waste generation per capita at the level of EU-27 countries (2020) in the period 2018-2022 -kg/capita-

Country	2018	2019	2020	2021	2022	2022/2018
Denmark	814	844	814	769	787	96.68%
Norway	739	776	604	736	768	103.92%
Luxembourg	803	791	790	793	721	89.79%
Belgium	409	416	729	755	677	165.53%
Switzerland	706	709	706	704	677	95.89%
Cyprus	662	664	625	650	673	101.66%
Malta	672	697	643	611	618	91.96%
Germany	606	609	641	651	593	97.85%
France	557	555	538	565	539	96.77%
Slovenia	486	504	487	511	487	100.21%
Croatia	432	445	418	447	478	110.65%
Slovakia	414	421	478	497	478	115.46%
Netherlands	511	508	533	515	473	92.56%
Spain	475	472	449	467	467	98.32%
Lithuania	464	472	483	480	465	100.22%
Hungary	381	387	403	416	406	106.56%
Sweden	434	449	431	418	395	91.01%
Estonia	405	369	383	395	373	92.10%
Poland	329	336	346	362	364	110.64%
Romania	272	280	290	302	301	110.66%
Bulgaria	407	442	408	445	-	-
Czechia	494	500	543	570	-	-
Ireland	598	625	644	-	-	-
Greece	515	524	499	509	-	-
Italy	499	503	487	495	-	-
Latvia	407	439	478	461	-	-
Austria	579	588	834	835	-	-
Portugal	507	513	513	513	-	-
Finland	551	566	609	630	-	-
Iceland	702	-	614	659	-	-

Source: Eurostat, accessed on April 2024

Analyzing the dynamics of municipal waste generation per capita at the European level, an upward trend is observed, with small fluctuations. The lowest amount generated per capita was 500 kg in 2018, and the highest 532 kg. In 2022, it reached 513, decreasing (-3.57%) compared to the one recorded in the previous year, but increasing (+2.6%) compared to the one in 2018 (Figure no. 6).

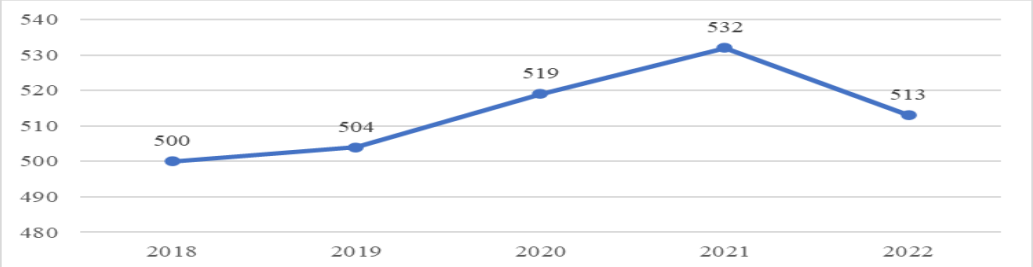

Figure no. 6. Dynamics of municipal waste generation per capita at EU-27 level (2020) -kg/capita-

Source: processing based on data provided by Eurostat, accessed on April 2024

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The next analyzed indicator is measured at European level as fresh mass along the entire food value chain. Cyprus is the country that generates the most food waste in the EU (397 kg/capita), followed by Denmark (221 kg/capita) and Greece (191 kg/capita). At the opposite pole, among the countries that generate the least food waste are: Spain (90 kg/capita), Sweden (89 kg/capita) and Croatia (71 kg/capita). Slovenia is the country that recorded the lowest amount of food waste in the EU, namely 68 kg/capita. It should be noted that Romania does not record values in the Eurostat database for this indicator in order to see where it ranks at the European level (Figure 7).

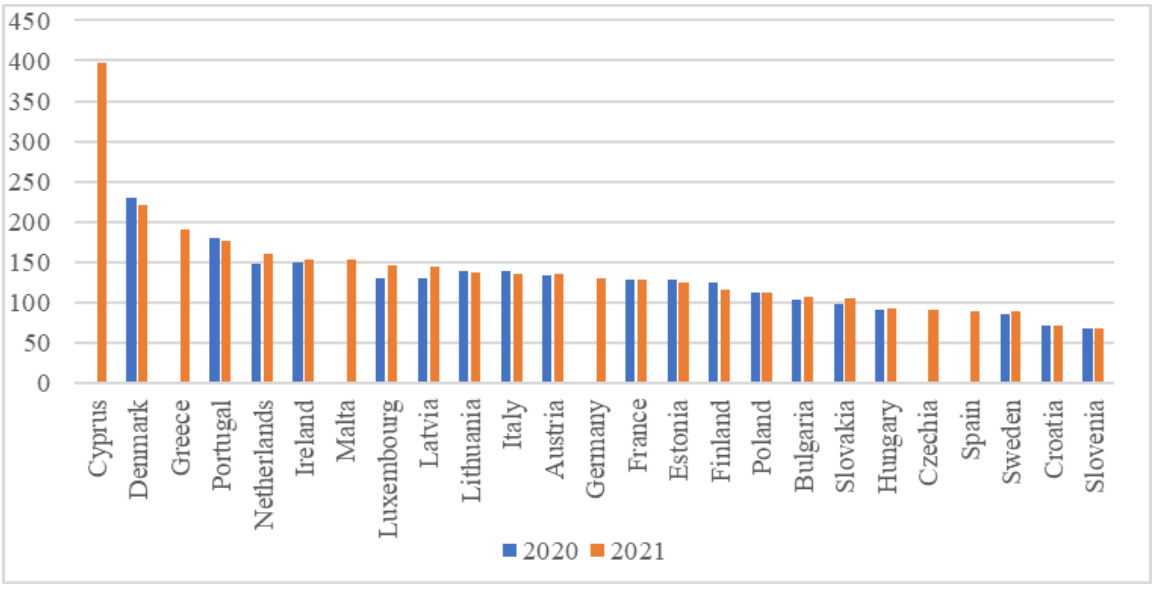

Figure no. 7. The amount of food waste generated per year divided by the average population of the country (Food waste) at EU-27 level (2020) -kg/ capita-
Source: processing based on data provided by Eurostat, accessed on April 2024

4. CONCLUSIONS

At the European level, the countries with the largest amounts of raw materials consumed in 2022 are: Finland with over 45 tons/capita, Denmark with over 34 tons/capita and Romania with over tons/capita, in while, on the last places there are countries such as Spain, the Netherlands and Malta with a quantity of raw materials consumed of 9.797, 6.762, and 6.648 tons/capita.

In terms of resource productivity, Switzerland (7.8783 euros/kg), the Netherlands (4.5753 euros/kg) and Luxembourg (4.3185 euros/kg) are the countries that achieved the highest productivities at European level. Romania recorded a productivity of 0.382 euro/kg in 2022, thus ranking last on the European level for this indicator.

When it comes to the amount of waste generated per capita, in 2020, Finland stands out for the largest amount of waste generated, 20.993 kg/capita, followed by Bulgaria which recorded 16.785 kg/capita. Romania ranks eighth in the ranking of European countries for this indicator, generating a quantity of 7.338 kg/capita. The country with the lowest amount of waste generated per capita in the last year available in statistics is Croatia, with 1.483 kg/capita.

Sustainable development changes the very nature of the economic environment, yes also of the social one. In this context, a radical rethink is needed by authorities, consumers and investors to make businesses a catalyst for tackling challenges from climate change to social change. Thus, investments in innovation, the transfer of technologies and green products, the promotion of

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sustainable and responsible behavior on the part of producers and consumers, and sustained efforts of awareness and civic involvement are essential in this respect. Without a package of national voluntary compliance measures coupled with the identification of economic instruments and the financing of the necessary investments, the achievement of the sustainable development objectives until 2030 planned at the European level will not be achieved.

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