

Mapping Romania's progress towards a circular economy using the EU Circular Economy Monitoring Framework

Silvia Ghiță-Mitrescu ^{1*}

^{1*} Ovidius University of Constanta (corresponding author, e-mail: silvia.mitrescu@365.univ-ovidius.ro)

Abstract – This paper examines Romania's progress in adopting the EU Circular Economy Monitoring Framework, assessing key performance indicators and identifying challenges in its transition towards a sustainable economic model. By analyzing data on the five main areas of the Monitoring Framework, the study highlights Romania's strengths and areas for improvement compared to the EU averages. The findings indicate an improvement in almost all categories of indicators but also underline the need for enhanced efforts.

Keywords – Circular economy, European Union, Romania, resource efficiency.

1. INTRODUCTION

Circular economy is an economic model designed to eliminate waste and maximize resource utilization through continuous cycles of reuse, repair, refurbishment, and recycling. Adopting a circular economy model has become a preoccupation for both scientists and regulators in the past decades. The European Union adopted in 2015 the first Circular Economy Action Plan and afterwards a Monitoring Framework was established for tracking and accelerating economic transformation across member states. For Romania, this framework offers both a strategic roadmap and a critical assessment tool for environmental and economic modernization.

This paper examines Romania's implementation of the EU Circular Economy Monitoring Framework, analyzing key performance indicators, identifying the achievements, and highlighting areas for improvement. By assessing the country's trajectory, the research aims to provide insights into Romania's sustainable development and its evolving role in the European economic system.

2. THEORETICAL BACKGROUND

Throughout history, scientists have been preoccupied with finding an economic model that can transform the resources consuming and environmentally damaging way of doing business to a more sustainable one. In 1996, economist Kenneth Boulding introduced the metaphorical concept "Spaceship Earth" in a seminal essay [1]. He argues that Earth is a

closed economic system with limited resources, challenging the prevailing economic model, and suggesting that economic activities should be conducted in a manner that minimizes waste and maximizes resource efficiency.

The first comprehensive exploration of a circular economy model can be found in the 1976 article “The potential for substituting manpower for energy” published by W. Stahel and G. Ready [2]. They introduced the concept of an economy in loops, emphasizing product life extension, reuse, repair, and recycling. Even before that, Georgescu-Roegen critiqued traditional economic models and introduced the concept of economic activities as thermodynamic processes in his 1971 book “The entropy law and the economic process” [3]. He considered economic systems as energy and material transformation processes, not just monetary exchanges. Building on Georgescu-Roegen’s work, H. Daly (1977) developed theories of steady-state economics, proposing economic models that incorporate ecological limits and acknowledge the existence of finite resources [4].

Nowadays, international organizations and authorities are increasingly preoccupied with defining the circular economy and establishing ways to implement the concept on a wider scale. We can find definitions of the concept from the World Economic Forum [5], The United Nations Environment Programme [6], or the European Union [7]. All definitions from the international institutions abovementioned emphasize minimizing waste as a core objective, focusing on extending the useful life of products and materials through different strategies like reuse, repair, and recycling. Circular economy is perceived as a comprehensive strategy and is set as a goal that challenges the traditional “take-make-dispose” economic model, replacing it with a more sustainable “reduce-reuse-recycle” concept.

Due to the complexity of the circular economy concept, along with the action plan that established the goals that countries must pursue in order to change their linear economic activities to circular ones, a monitoring framework was needed to track the progress. In December 2015, the European Commission adopted the first circular economy action plan [8]. It contained 54 actions that by now have either been delivered or are being implemented. To track the progress for the actions proposed by the Circular Economy Action Plan, a Monitoring Framework was developed in 2018 by Eurostat, containing indicators for its main thematic areas. In March 2020, a new version of the Action Plan was established, as part of the European Green Deal. This new action plan contains measures aimed at making sustainable products the norm in the EU, empowering consumers and public buyers, ensuring less waste, leading global efforts on circular economy, and focusing on the sectors that use most resources and where the potential for circularity is high [7]. Based on the development of the action plan, a revised Monitoring Framework was created in 2023, including new indicators on material footprint, resource productivity, and consumption footprint.

Romania is actively working to transition towards a circular economy, aligning with the European Union's sustainability objectives. The country has developed strategic frameworks and action plans to guide this transition, focusing on key sectors and establishing monitoring mechanisms. Adopted in 2022, the National Circular Economy Strategy (NCES) outlines Romania's roadmap for shifting from a linear to a circular economic model. It emphasizes the development of indicators sourced from Eurostat, the National Institute of Statistics, and existing regulations to monitor progress across social, economic, and environmental dimensions [9].

3. RESULTS AND DISCUSSION

The following section offers a detailed description of the indicators included in the EU Circular Economy Monitoring Framework. The indicators are structured into the five main areas of the Framework. For each indicator, a short description of the role and importance is presented, followed by the most recent available data for Romania and the EU-27 average (to allow for comparison and conclusions about Romania's progress).

1. Production and consumption - this section contains indicators focused on resource use, waste generation, and sustainable consumption patterns. It can be divided into two thematic areas:

1. Material consumption – consists of indicators that measure the demand for material extraction and the efficiency of material use. The two main indicators of material consumption are:

- **Material footprint** (raw material consumption) – measures the demand for raw materials (such as minerals, biomass, fossil fuels, metals) extracted globally to meet the EU's consumption and investments needs. A high value of material footprint indicates resource inefficiency, while a lower footprint suggests more sustainable consumption.

- **Resource productivity** – measures the efficiency of materials consumption, by dividing the gross domestic product by domestic material use. Efficient material use helps reduce environmental pressure and impact; therefore, high material productivity means more value is created per unit of resource used.

Table 1. Evolution of material consumption indicators in EU and Romania

Indicator		2019	2020	2021	2022	2023
Raw material consumption (tons per capita)	EU-27	15.03	14.376	14.784	14.736	14.071
	RO	27.96	29.371	30.493	30.367	33.125
Resource productivity (euro per kg. chain linked volumes -2015)	EU-27	2.0697	2.0411	2.0768	2.1693	2.2297
	RO	0.3684	0.3448	0.3559	0.3748	0.3461

Data source: Eurostat [10]

While the EU-27 demonstrates a consistent trend of reducing raw material consumption (6.4% over the five years period, with the most significant decline between 2022 and 2023) and improving resource productivity (7.7% total increase, with a steady year-on-year growth except a slight decrease in 2020), Romania shows an opposite trajectory with increasing material consumption (18.5% over five years, with the steepest increase of almost 9% between 2022 and 2023, being nearly 2.4 times higher than the EU-27 average) and inconsistent economic efficiency. The data suggests that Romania still encounters significant challenges in its transition towards a more sustainable and circular economic model.

2. Waste generation – containing indicators that measure the amount of waste, both in general and by specific types of waste, being generated by inhabitants. Minimizing waste generation is a key part of the Circular Economy Action Plan, waste being considered a resource. High waste generation indicates inefficient consumption and disposal practices, while reducing waste supports circularity. This section includes six indicators, the most important of which are:

- **Total waste generation per capita** – defined as the total waste generated in a country, including major mineral wastes, divided by the average population of the country.
- **Generation of municipal waste per capita** – measures the waste collected by or on behalf of municipal authorities and disposed of through the waste management system.
- **Food waste per capita** – measures the food wasted in the production, distribution, and food services stages, as well as by households.
- **Generation of packaging waste per capita** – measures the total value of packaging waste being generated in an economy. In the context of this indicator, all products used for the containment, production, handling, delivery, and presentation of goods, from the producer to the user, regardless of the material that they are made of, are considered as “packaging”.

Table 2. Evolution of waste generation indicators in EU and Romania

Indicator		2014	2016	2018	2020	2022
Total waste generation (kg per capita)	EU-27	4785	4858	4891	4824	4604
	RO	8871	9012	10425	7344	8410
		2018	2019	2020	2021	2022
Municipal waste generation (kg per capita)	EU-27	500	505	521	534	515
	RO	272	280	290	302	303
Food waste (kg per capita)	EU-27	-	-	128	129	127
	RO	-	-	166	177	181
Packaging waste generation (kg per capita)	EU-27	173.25	177.49	178.01	190.07	186.49
	RO	80.47	103.81	116.38	127.21	-

Data source: Eurostat [10]

In this category of indicators, Romania demonstrates more volatile waste generation patterns than the EU-27. For total waste generation, EU-27 shows a gradual decline, while Romania registered fluctuations, 17.6% increase between 2014 and 2018, 29.6% decrease between 2018 and 2020, and 14.5% increase from 2020 to 2022. The data also reveals that Romania’s municipal waste generation increased, as well as food waste, and packaging waste. However, both municipal waste generation and packaging waste generation are below the EU-27 average.

II. Waste management – is one of the key pillars of EU Circular Economy Monitoring Framework and contains indicators aimed at tracking how efficiently waste is managed, recycled, and reintegrated in the economy. As previously mentioned, waste is considered to be a resource. Its correct management allows for better allocation and use of materials, promoting a closed-loop economic system. Indicators from this section determine the percentage of waste, either in general or from a specific category, that is collected, treated, and turned into new materials rather than being landfilled or incinerated. They can be divided into two sections:

1. Overall recycling rates – includes indicators related to the rate of recycling municipal waste, the most important of which is **Recycling rate of municipal waste** – indicates how much waste generated by final consumers (mainly households and sources that are similar in nature and composition of waste) is used as a resource in the circular economy. A higher recycling rate indicates better waste separation, collection, and processing systems, being a good indicator of the quality of the overall waste management system.

2. Recycling rates for specific waste streams – offer insides on the waste management of various types of waste, the most important of which are:

- **Recycling rate of overall packaging** – the indicator is used to monitor progress towards the 65% and 70% packaging recycling target set for 2025 and 2030. Packaging waste is a major source of pollution, higher recycling rates leading to the reduction of resource extraction and environmental damage.

- **Recycling rates for packaging waste by type of material** – offers details on the recycling rates for each type of packaging material, such as paper, plastic, glass, wood, metal.

- **Recycling rate for WEEE separately collected** – WEEE (waste electrical and electronic equipment), also known as e-waste (computers, televisions, mobile phones, home appliances) is one of the fastest growing waste streams in the world. Ensuring high recycling rates in these categories helps recover valuable materials and prevents hazardous waste leakage into the environment.

Table 3. Evolution of waste management indicators in EU and Romania

Indicator – recycling rate of (%)		2018	2019	2020	2021	2022
Municipal waste	EU-27	46.4	47.2	48.8	49.9	49.1
	RO	11.1	11.5	11.9	11.3	12.3
Overall packaging	EU-27	65.6	64.8	64	64	65.4
	RO	57.9	44.6	39.9	38.3	-
Paper and cardboard packaging	EU-27	84.2	82.1	81.5	82.8	83.2
	RO	88.9	68.3	63.2	67.9	-
Plastic packaging	EU-27	41.4	41.1	37.6	40.3	40.7
	RO	43	31.1	30.1	31.6	-
Wooden packaging	EU-27	29.3	30.9	31.9	32.1	34.2
	RO	28.4	24.8	16.6	15.7	-
Metallic packaging	EU-27	82.9	81.2	75.7	75	76.9
	RO	58.7	49.6	51.1	44.2	-
Glass packaging	EU-27	75.8	75.6	76	74.1	75.6
	RO	61.1	42.9	42.7	28	-
WEEE separately collected	EU-27	81.7	81.3	83.2	81.6	80.7
	RO	83.1	81.5	76	79	-

Data source: Eurostat [10]

Municipal waste management in Romania continues to be a significant problem. The evolution of the indicator reveals a minimum and inconsistent growth rate and a significant gap between EU average (around 49%) and Romania (11-12%). When it comes to packaging materials waste management, Romania consistently falls behind the EU average in recycling rates for most materials, with declining rates and considerable smaller values compared to EU averages. The only category where the level of recycling rates is comparable with the EU values and follows the same trend in WEEE separately collected.

III. Secondary raw materials – are recycled materials reintroduced into the economy to replace virgin resources. Using secondary raw materials is important for reducing environmental impact, lowering raw materials dependency, and promoting a circular economy. This category of indicators track how effectively secondary raw materials are integrated into production and consumption. It consists of two thematic areas:

1. Contribution of recycled materials to raw materials demand – measures the percentage of materials used in an economy that comes from recycled sources instead of newly extracted materials. The indicator used to quantify the contribution of recycled materials to overall materials demand is called **circular material use rate**. A higher circular material use rate means that the economy relies less on virgin resources, reducing environmental degradation and resource scarcity.

2. Trade in recyclable raw materials – this section of indicators is dedicated to the measurement of the quantity of recyclable waste, scrap, and other secondary raw materials that is traded between EU member states and across the EU borders. Trading secondary raw materials ensures efficient resource distribution and supports circular supply chains. It also reduces dependence on primary material imports from non-EU countries. High trade volumes indicate that recycled materials are being reintegrated into production. The volume of trade in recycled materials is quantified using three indicators: **imports from non-EU countries**, **exports to non-EU countries**, and **intra-EU trade**.

Table 4. Evolution of secondary raw materials indicators in EU and Romania

Indicator		2019	2020	2021	2022	2023
Circular material use rate (percentage)	EU-27	11.2	11.2	11.1	11.5	11.8
	RO	1.4	1.5	1.5	1.5	1.3
Imports from non-EU countries (thousand tons)	EU-27	40775.4	39778.6	41449.8	40824.2	39835.3
	RO	679.4	638.1	706.7	817.6	910.1
Exports to non-EU countries (thousand tons)	EU-27	35625.4	36738.4	37607.5	36473.1	39267.5
	RO	1499.9	1872.8	2018.0	1676.5	1883.2
Intra-EU trade (thousand tons)	EU-27	84734.4	83055.9	91536.7	86463.4	82445.6
	RO	833.5	776.4	868.6	817.1	765.6

Data source: Eurostat [10]

Circular material use rate demonstrates a gradual improvement at EU level, consistently increasing from 11.2% in 2019 to 11.8% in 2023, while for Romania the values are significantly below the EU average, fluctuating between 1.3% and 1.5%. The trade in recyclable raw materials at the EU level shows a relatively stable level of imports from non-EU countries, a moderate increase in exports to non-EU countries, and no clear consistent trend of intra-EU trade. In Romania's case, imports from non-EU countries increased with about 34% from 2019 to 2023, exports to non-EU countries fluctuated but generally increased also, while intra-EU trade remained relatively stable at around 800 thousand tons.

IV. Competitiveness and innovation – are key drivers of the circular economy. They ensure that new technologies, business models, and market opportunities are being developed. This section of the EU Circular Economy Monitoring Framework measures economic growth, job creation, and investment in circular solutions. Indicators of competitiveness and innovation are important because they track economic benefits of circular economy, support job creation in sustainable industries, and encourage businesses to invest in green innovation. There are two main components of this section of the Framework:

1. Private investment, job and gross value added related to circular economy sectors – measure **investment levels in circular economy activities**, **number of jobs created** in circular economy sectors, and the **economic contribution of circular economy**

businesses to GDP. More investment levels signal stronger market confidence in circular solutions, increased employment in circular sectors suggest a growing green job market, and gross value added indicates how profitable and scalable the circular economy is for businesses.

2. Innovation – assess the **number of patents granted** for innovations in recycling technologies, material recovery, and circular production processes. The emphasis is placed on patents related to waste management, material reuse, and resource efficiency. The significance of this analysis stems from the fact that patents serve as a reliable indicator of innovation and technological progress within the domain of circular economy industries. An increase in the number of patents indicates that businesses and research institutions are prioritizing circular solutions, thereby aligning with the EU's objective of attaining global leadership in sustainable technologies.

Table 5. Evolution of competitiveness and innovation indicators in EU and Romania

Indicator		2017	2018	2019	2020	2021
Private investments (percentage of GDP at current prices)	EU-27	0.8	0.8	0.8	0.9	0.8
	RO	0.6	0.4	0.5	0.5	0.5
Gross value added (percentage of GDP at current prices)	EU-27	2	2.1	2	2.2	2.1
	RO	1.1	1.1	1.1	1	1
Persons employed (percentage of all employment)	EU-27	2.1	2.1	2.1	2.1	2.2
	RO	2.4	2.3	2.4	2.4	2.8
Patents related to waste management and recycling (number)	EU-27	309.21	316.13	385.71	206.55	-
	RO	8.49	9.5	7.9	5	-

Data source: Eurostat [10]

In this category, Romania demonstrates consistent economic potential with room for improvement in investment and value-added sectors. While lagging behind EU-27 averages, the country shows promising employment growth and private investments relative stability during the observed period.

V. Global sustainability and resilience – this newest section of indicators from the Monitoring Framework investigates how the EU's circular economy efforts contribute to climate goals, environmental sustainability, and resource security. These indicators help measure the reduction of environmental impact and the EU's reliance on non-renewable resources, ensuring long-term resilience and sustainable development. The most important indicators in this category are:

1. Consumption footprint – evaluates the environmental impact of EU consumption, considering the entire lifecycle of goods and services. It is a tool that quantifies the environmental impact of EU consumption. It encompasses a wide range of factors, including resource extraction, production and manufacturing, and use and disposal. The indicator considers multiple impact areas, such as climate change (carbon footprint), air and water pollution, land and biodiversity degradation, and water and energy use. The importance of the Consumption Footprint Indicator lies in its ability to track the environmental impact of EU consumption both within and outside of Europe. It serves as a catalyst for sustainable consumption and production by illuminating which sectors bear the greatest environmental burden.

2. Greenhouse gas (GHG) emissions from production – includes the emissions of greenhouse gases by all production activities, including production of both goods and services. It excludes emissions by households for heating, transportation and other purposes. Circular efficiency and cut emissions by reducing resource extraction, improving energy efficiency, and promoting material reuse. A decrease in greenhouse gas emissions means a higher contribution to climate change mitigation.

3. Material import dependency - is the extent to which an economy relies upon imports in order to meet its material needs. It is very important to control and decrease import dependency, especially fossil energy materials. A higher self-sufficiency rate means the EU can sustain its industries with less exposure to global supply chain disruptions, increasing economic and geopolitical resilience.

Table 6. Evolution of global sustainability and resilience indicators in EU and Romania

Indicator		2019	2020	2021	2022	2023
Consumption footprint (index 2010 = 100)	EU-27	108	103	106	109	-
	RO	108	107	111	114	-
GHG emissions from production (kg per capita)	EU-27	6864.5	6172.3	6541.0	6464.8	5965.4
	RO	5067.7	4851.9	5003.0	4748.4	4660.5
Material import dependency (percentage)	EU-27	23.7	22.2	22.6	23.7	22
	RO	9.5	9.3	10.1	9.9	8.1

Data source: Eurostat

Even though the consumption footprint indicator increased for both EU-27 average and Romania during the analyzed period, Romania demonstrates a more robust consumption growth compared to the EU-27 average. Greenhouse gas emissions for both EU and Romania show consistent emissions reduction, with Romania maintaining lower per capita emissions compared to the EU average. Also, Romania registers lower material import reliance compared to the EU average.

4. CONCLUSIONS

The use of metal in civil engineering was a modern phenomenon, manifested under the highest demands, in the southern area of the Carpathians and represented an attitude in the promotion of both modern materials but also in ensuring the resistance and stability of the construction.

5. REFERENCES

- [1] Boulding, K.E. (1966), *The economics of the coming spaceship earth*, in H. Jarrett (Ed.), *Environmental quality in a growing economy*, pp. 3-14, Johns Hopkins University Press
- [2] Stahel, W., & Reday, G. (1976), *The potential for substituting manpower for energy*. Research Report to the European Commission, Industrial Systems and Technological Planning Unit
- [3] Georgescu-Roegen, N. (1971), *The entropy law and the economic process*. Harvard University Press

- [4] Daly, H. E. (1977), *Steady-state economics*. W.H. Freeman and Company
- [5] World Economic Forum (2019), *Circular economy: Insights and approaches for accelerated transformation*. WEF Global Agenda Publications
- [6] United Nations Environment Programme (2020), *Circularity: Rethinking our economic model*. UNEP Sustainable Systems and Consumption Report
- [7] European Commission (2020), *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, A new Circular Economy Action Plan For a cleaner and more competitive Europe (COM/2020/98 Final)*, European Commission: Brussels, Belgium
- [8] European Commission (2015), *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Closing the Loop—An EU Action Plan for the Circular Economy (COM(2015) 614 Final)*; European Commission: Brussels, Belgium
- [9] Romanian Government (2022), *National Strategy for the Circular Economy*, Of. M. no. 943/27.09.2022
- [10] Eurostat Database: <https://ec.europa.eu/eurostat/web/circular-economy/monitoring-framework>