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European Circular Economy Policy-Making in Sustainability and Resource Management Development

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Abstract
The study examines the development policy of the circular economy using the example of European Union countries based on the results of their circularity indicators. The respective countries fall into the "shift" country profile according to the distribution from the Global Circularity Gap, being consumers of the majority of global materials and generating 43% of emissions. Through the grouping of EU countries, it was found that high-circularity indicators do not necessarily determine a country's level of environmental friendliness. It has been identified that countries with high resource productivity levels (ranging from 5.8811 to 2.1397%), provided they have high and medium levels of product processing and investment in circular economy development, do not always have a positive impact on the environment. The corresponding research has led to the conclusion that the significant negative impact of the overproduction of goods and excessive resource consumption in European countries, which necessitates appropriate changes in societal activities. There is a need to adjust the policy directions of EU countries to stimulate their sustainable development in a closed-loop economy context, taking into account the specific characteristics and opportunities of each country, which will ensure a more effective adaptation to the implemented innovations. The results of this research can be applied to shaping the circular economy development policy and developing proposals for directions in societal development based on raising awareness about the consequences of interactions with the environment.

Keywords- Circular economy, Circularity indicators, Natural resources management, Societal awareness.

1. Introduction

Globalization, the excessive consumption of food products, and natural resources contribute to a range of environmental problems that negatively impact economic and social development. The depletion of natural resources and environmental pollution hinder economic growth and sustainability.

Addressing these issues is possible through international initiatives and should involve timely changes in production processes, rational use of natural resources, and the development of circular economy sectors aimed at efficient material management, recycling, and waste management.

The transition from a linear economic model, where the focus was primarily on production and processing, to a circular one, based on the "production-use-recycling" principle, involves extending the lifecycle of used materials, thereby reducing the extraction of natural resources and environmental pollution. However, this transition has posed several challenges for rapid resolution: inefficient use of natural resources, shifting the world's dependence from primary to recycled resources, establishing effective waste management, redirecting societal thinking, reducing human strain during the transition to a circular economy, developing recycling industries, exploring ways to replenish natural resources, and implementing and advancing renewable energy solutions (Prokayeva, 2021).

The potential of a circular economy has drawn the attention of various researchers, who see it as a guarantee of sustainable development (Korhonen et al., 2018) and a solution to environmental problems (Geissdoerfer et al., 2018). Significant attention has been paid to the development of circularity at the industry and entrepreneurial levels, with research dedicated to constructing and developing business models, implementing zero-waste production in companies, and promoting cooperation among industries for secondary material processing (Ayeleru et al., 2018).

The concept of a circular economy encompasses all processes of commodity production from planning goods with extended usage periods to the potential for recycling or restoration (Potapenko, 2012). The transition to a closed-loop economy requires a shift in human perception and demands systematic, structural, and organized efforts (Grieze and Miķelsone, 2021). The Ellen MacArthur Foundation, one of the world's leading experts in circular economy, defines it as a comprehensive systemic solution to address global issues such as climate change, biodiversity loss, waste management, and environmental pollution based on waste and pollution reduction principles, product and material circularity, and the regeneration of natural resources (Watkins and Meysner, 2022).

The goal of a circular economy is to eliminate waste by extending the lifespan and utilization of resources, materials, goods, and products. It involves redesigning business processes by rethinking the necessity of preserving natural resources, developing innovative solutions, and incentivizing the adoption of more sustainable resource consumption models. This societal development direction will contribute to reducing material and energy consumption, waste generation, greenhouse gas emissions, environmental pollution, and global employment by 7-8 million jobs by 2030 (European Investment Bank, 2023). International and domestic integration of efforts towards circular economy development is essential to effectively conserving and protecting the environment. The transition to a circular economy in European Union countries began in 2015 with the launch of the first action plan. In 2020, the European Commission adopted a new action plan that shifted the focus from waste to extending the product life cycle or reducing

overproduction. Achieving absolute resource consumption reduction for a fully closed-loop economy in the EU is currently not feasible (European Commission, 2023).

Analysing the chronology of circular economy development policies allows us to trace the main interconnections between sectors to achieve environmental sustainability and form potential directions for planning future strategies. In 2015, the European Commission adopted the first circular economy action plan, primarily focusing on waste management innovation. Today, circular economy policies have expanded their scope to various sectors of the economy, including resource conservation and restoration (while ensuring the competitiveness of European countries), regulation of eco-design, chemical content in products, plastic and battery usage, product labelling, packaging use restrictions, and limitations on biodegradable and compostable plastics (European Commission, 2023).

The essence and possibilities of the circular economy were initially presented by Boulding (1966), who argued that the Earth has limited resources and humans must define their role in the ecological cycle. Starting in the 1990s, the idea of implementing and developing the circular economy evolved into a necessity as society became aware of the negative environmental impacts and corresponding policy measures were implemented, such as assigning a cost to negative environmental impacts. Today, according to research from the University of Oxford, the circular economy assists in addressing climate issues and serves as a means for developing an inclusive green economy (Haney et al., 2019). Lacy et al. (2020) believe that the circular economy will facilitate the transition stages of reducing or ceasing the use of rare resources and harmful substances.

Research on the development of the EU circular economy has garnered the attention of several scholars who have raised various questions in the following directions: interdependence of sustainable development and the circular economy (Bauwens, 2021; Kirchherr, 2022; Schröder et al., 2020); identification of key directions for the development and implementation of the circular economy (Horbal and Lomaha, 2022) analysis of the principles of the circular economy and implementation of relevant business models for zero-waste production (Centobelli et al., 2020; Zaman, 2015); methodological support for the analysis and assessment of the development of the circular economy (Shubaly et al., 2023); eco-innovation and issues related to the development of circular economy businesses (Calisto Friant et al., 2021; Gaddy et al., 2017; Ormazabal et al., 2018); the need to accelerate circular economic development due to the insufficient pace of progress in the context of modern policy implementation (Adams et al., 2017; Liu and Bai, 2014; Masi et al., 2018; Xue et al., 2010).

The effective development of a circular economy policy depends on the level of penetration of its principles across all spheres and sectors of society's economy (Apollon et al., 2022). Achieving the main goal of preserving the planet's resources and protecting the environment is possible only through mutual cooperation. This underscores the need for further research to determine optimal measures for sustainable development based on the expansion of the circular economy.

The purpose of this study is to conduct research aimed at determining the vector of development for countries worldwide to build a circular economy. This involves identifying the specific aspects of this process, which will allow for the identification of priority development directions for the fundamental components necessary for organizing a circular economy in countries that are in the early stages of development in this direction.

The main goal is to create a guideline for focus by identifying the main components that drive a closed-loop economy. In line with the established goal, the following tasks were planned:

- Identify directions for meeting society's needs within the safe boundaries of the planet in order to develop a circular economy.
- Establish country profiles based on global circularity Gap grouping to determine more effective development solutions for specific groups of countries.
- Analyse indicators related to material use, processing, self-sufficiency in raw materials, and the dynamics of the material circularity rate in EU countries that fall under the "Shift" group based on CGR distribution and are consumers of the majority of global materials, generating 43% of the emissions.
- Investigate the dynamics of the material circularity rate in EU countries from 2010 to 2021.
- Examine the fundamental directions for the development of a circular economy in countries.
- Conduct research into the interdependence of EU countries' economic development processes, exemplified by the analysis of their circularity indicators from 2019 to 2021.
- Formulate conclusions based on the research conducted and propose recommendations aimed at promoting the development of European circular economy policies in the context of sustainable development and efficient resource management.

2. Theoretical Frameworks

Political measures aimed at building a circular economy in EU countries are key driving factors for sustainable development. Researchers in this field employ a wide range of methods to conduct comprehensive analyses and identify ways to improve policy impacts. These methods include combining qualitative and quantitative research (Friant et al., 2020), empirical surveys, a comprehensive review of legislative and policy directions in EU countries (Domenech and Bahn-Walkowiak, 2019), research on the life cycle of resources, and the development of three policy areas (reuse, green public procurement, and improving secondary raw-material markets) (Milios, 2018). Each of these approaches has its advantages, as it allows for the identification of specific nuances and intricacies within the chosen research focus.

In this regard, there is a need for further research on European circular economy policies, with a focus on promoting sustainable development in EU countries and the efficient use of resources. This requires identifying the characteristics of the circulation indicator results for specific European countries.

The research was based on the use of statistical observation methods (Global Circularity Gap) and clustering to summarize the main strategic direction for the development of the world's circular economy. This direction is based on the development of societal thinking, increasing humanity's awareness of ending excessive consumption, and implementing rational material use. Using the case of 27 European countries, the interdependence between specific circularity indicators was analysed through clustering. During the observation and comparison process, it was revealed that the level of circularity indicators can vary within a single country, which does not provide reliable information about the achieved level of circular economy development. It depends on the national peculiarities of a particular country, relationships, and values.

Analysing the development directions of developing countries, it was found that their strategic policies are based on the circular economy, allowing for a conclusion about the global reach of the circular economy. The analysis of circularity indicators in European Union countries was conducted based on (European Investment Bank, 2023; European Commission, 2023).

(i) The Consumption Footprint indicator evaluates the environmental impact of consumption in the EU and member states by combining data on consumption intensity and the ecological impacts of products.

Consumption Footprint: It consists of a set of 16 indicators based on a life cycle assessment (also available as a single composite indicator). It combines i) emissions to air, soil, and water; ii) resources used throughout the life cycle of about 160 typical products within 5 consumption domains (food, mobility, housing, consumer goods, and appliances); and iii) the Ecological Footprint (EF) methodology, which converts emissions and resource use into potential ecological impacts. The consumption indicator reflects the overall per capita value of Environmental Footprint categories and is calculated as the sum of the characterized value (absolute) of each impact category (i) divided by a normalization factor reflecting the global impact, multiplied by the EF weighting set (1):

$$\sum_{i=0}^{i=16} \frac{Abcolute\ per\ capita\ i\ (EF\ metric)}{Normalization\ factor\ i\ (EF\ metric)} * Weighting\ factor\ i \quad (1)$$

The Consumption Index (base=2010) reflects the consumption footprint compared to the year 2010, which serves as the reference year. The index for a specific impact category (i) in a given year (j) is calculated as the ratio between the absolute value for that year divided by the value for the year 2010 (2).

$$\text{Abssolute per capita } i, j \text{ (EF metric)} / \text{Absolute per capita } i, 2010 \text{ (EF metric)} \quad (2)$$

(ii) Gross investments in tangible goods and value added at factor cost are used to monitor progress in a closed-loop economy when analysing the section on "Competitiveness and Innovation."

(iii) The household waste recycling rate, which indicates how *j* consumer waste is utilized as a resource in a circular economy (3):

$$(\text{Total waste generation} / \text{Volume of household waste}) * 100 \quad (3)$$

(iv) Level of recycling for all types of waste, excluding major mineral waste (4):

$$(PV/ZOV) * 100 \quad (4)$$

PV – stands for Processed Waste, which refers to waste that has been treated or processed for disposal; ZOV – represents the Total Amount of Processed Waste, excluding primary mineral waste.

(v) The number of individuals employed in circular economy sectors and analysing job positions allow us to assess whether the transition to a circular economy yields the expected results.

3. Results

In order to transition to a circular economy, the EU has implemented a series of policy measures that encompass various sectors of the economy (Boulding, 1966). The European Commission's proposed action plan for circular economy development aims to promote the environmental friendliness of products, reduce waste generation, and expand consumer opportunities for prolonging the product lifecycle through repair and product servicing.

Emphasis has been placed on resource-intensive sectors of the economy such as electronics, ICT, plastics manufacturing, textiles, and construction. In turn, the resolution on the new circular economy action plan aims to broaden measures towards achieving carbon neutrality and environmental sustainability, including the elimination of toxic substances, the development of recycling industries, and a complete transition to a circular economy by 2050.

Over time, European policy has included proposals to accelerate the development of the circular economy, which involves increasing the environmental friendliness of products, expanding consumer

opportunities for eco-friendly choices, making changes in legislation regarding construction products and the production of eco-friendly textiles, and implementing a range of initiatives within the action plan to reduce the impact of microplastic pollution on the environment.

Tracking the chronology of progress in circular economy development policies allows us to trace the main interconnections between sectors to achieve environmental sustainability and identify potential directions for planning future strategies (Table 1).

Table 1. European policies on circular economy development progress (European Commission, 2023).

Date	List of Measures
December 2015	The European Commission adopted the first Circular Economy Action Plan, which included measures aimed at stimulating Europe's transition to a circular economy, enhancing global competitiveness, promoting sustainable economic growth, and creating new jobs
November 2016	Adoption of the Eco-design Working Plan for 2016-2019
January 2018	The European Commission approved a package for the development of the circular economy, including monitoring, a plastics strategy, measures to reduce the presence of hazardous substances in products, and more
July 2018	Entry into force of the legislative framework on waste (EU Regulation 2018/848 of the European Parliament and of the Council on organic production and labeling of organic products, etc.)
March 2019	Adoption by the European Commission of the final Circular Economy Package
June 2019	Entry into force of the fertilizer regulation (EU Regulation 2019/1009 of the European Parliament and of the Council)
July 2019	Entry into force of the directive on single-use plastics (EU Directive 2019/904 of the European Parliament and of the Council)
October 2019	Adoption of 10 delegated acts on ecodesign
December 2019	The European Commission adopted the European Green Deal
March 11, 2020	The European Commission adopted the New Circular Economy Action Plan for a cleaner and more competitive Europe
December 10, 2020	The European Commission adopted a proposal for a new regulation to address the environmental impact of the increasing demand for batteries (COM (2020) 798 final; 2020/0353(COD))
February 22, 2021	Launch of the Global Alliance on Circular Economy and Resource Efficiency (GACERE)
October 28, 2021	The European Commission adopted a proposal to update rules on persistent organic pollutants in waste
November 17, 2021	The European Commission adopted a proposal for updated rules for the transboundary shipment of waste
March 30, 2022	The European Commission adopted a package of measures on eco-friendly products, the regulation of their ecodesign, environmentally safe textiles, construction, and expanding consumer options during the transition to ecologism
April 5, 2022	The European Commission adopted a proposal to review EU measures to combat industrial pollution (industrial emissions, polluting substances)
November 30, 2022	The European Commission adopted measures as part of proposed actions for the development of the circular economy (review of EU packaging and packaging waste rules, restrictions on biodegradable and compostable plastics)
March 22, 2023	The European Commission adopted a proposal on environmental requirements and the right to repair
May 2023	Review of the European Commission's closed-loop economy monitoring system

In order to develop a circular economy, a set of indicators has been formulated to determine the efficiency of production and consumption systems of material and natural resources in countries, the movement and subsequent life cycle of waste, and more.

These indicators serve as a pathway towards achieving zero environmental pollution by monitoring the alignment of economies with sustainable development, assessing the impact of countries' economic activities on the environment, the dependence on imported raw materials, and a country's self-sufficiency in raw materials, among other factors.

Currently, only 7.2% of the global economy is circular (CGR, 2023). This situation worsens annually due to the increasing extraction and use of materials. In 2023, compared to 2020, the global circularity rate has dropped by 1.4 percentage points, and compared to 2018, it has dropped by 1.9 percentage points. This indicates that currently more than 90% of materials are either spent or unavailable for reuse for years due to being locked in long-term stocks as fixed assets. According to calculations by the Global Circularity Gap (CGR), the development of a circular economy can reduce global material extraction and

use by one-third. Circular solutions in four key systems (Figure 1) can eliminate excess use of resources and extraction, enabling society's needs to be met within planetary boundaries (CGR, 2023).

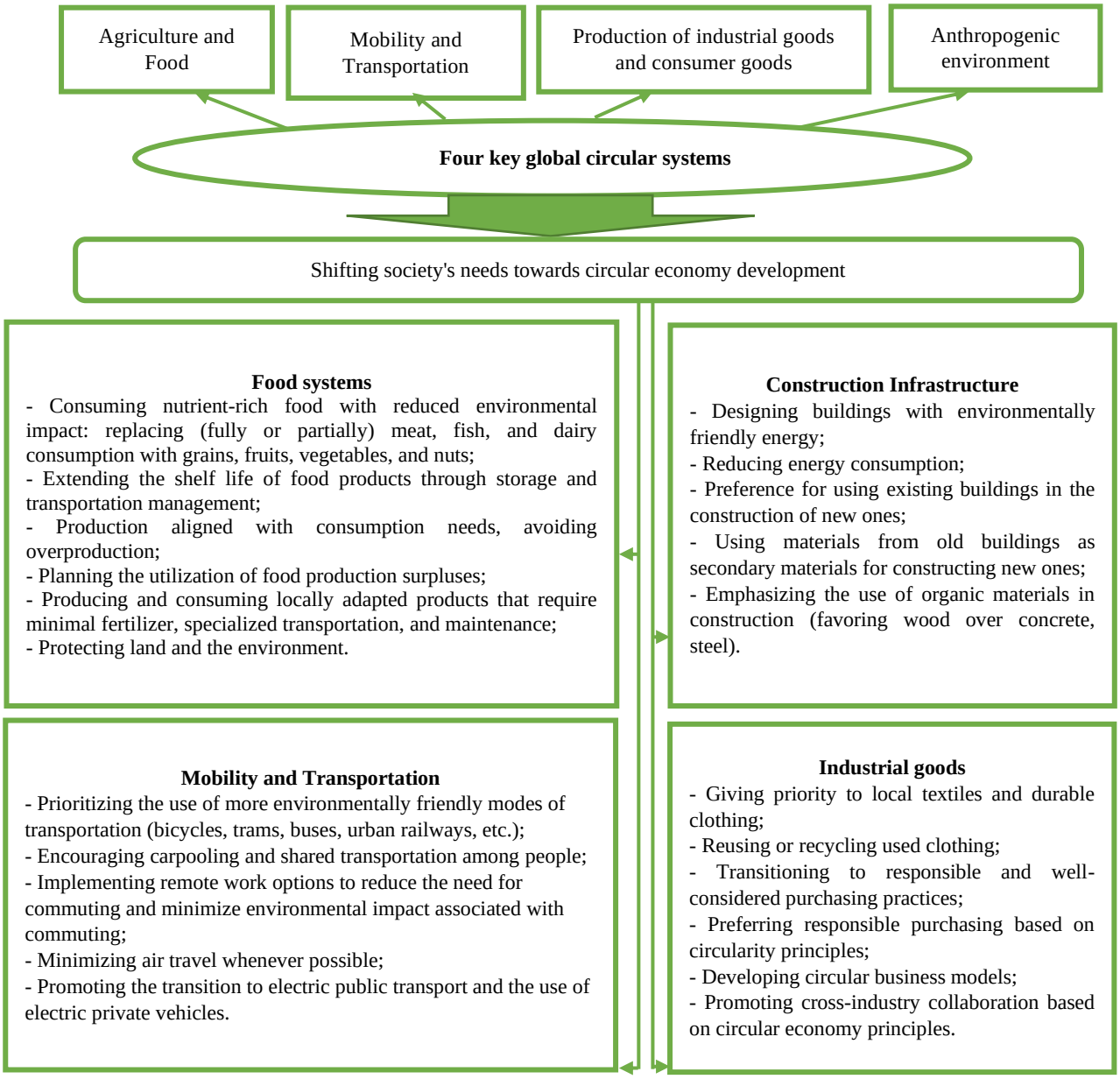


Figure 1. Directions for meeting society's needs within the safe boundaries of the planet for the development of the circular economy. Source: based on (CGR, 2023).

The "take-make-dispose" economy depletes natural resources, negatively impacts plant and animal species, contributes to increased toxin levels in soil and water, and pollutes the air. Rapid resource extraction leads to three critical global issues: climate change, resource depletion, and environmental damage. The development of scientific and technological progress expands the need for energy, security,

and resources, which predicts the growth of these aforementioned problems. In order to prevent these issues, the circular economy aims to ensure that economic growth follows the principles of sustainable development, thereby preventing harm to the environment through a balanced relationship between humanity and the environment.

The European Investment Bank, the lending arm of the European Union, has provided 3.4 billion euros in co-financing for 118 circular economy development projects across various sectors from 2018 to 2022. These sectors include industry and services (35%), agriculture and bioeconomy (23%), micro-enterprises focusing on waste management (22%), water management (6%), construction industry (3%), and others (8). Circular economy projects encompass various strategies to preserve materials, energy, and labor used in the production process, such as:

- Utilizing cellulose from used clothing to produce new fabrics through the construction of a full-scale textile recycling plant (Renewcell, a Swedish company) (Renewcell, 2023);
- Adopting advanced and sustainable polyolefin solutions for polyolefin recycling to address climate, energy, food, health, water, sanitation, waste, and recycling challenges (Borealis, an Austrian company with production facilities worldwide) (Borealis, 2023);
- Providing financing to innovative companies and projects in the field of bioeconomy and circular bioeconomy in the European Union and Horizon countries, focusing on value creation from food waste streams (PeelPioneers, 2023); and the development of plant proteins and milk alternatives (Prolupin, 2023);
- Reducing dependence on imported titanium through the construction of the first industrial plant in the EU for the recycling and remelting of titanium scrap metal and titanium alloys (France) (European Investment Bank, 2023);
- Manufacturing particle boards and furniture from recycled wood, including pallets, used furniture, and garden trimmings, by cleaning and processing them into new wooden panels (Saviola Holding, 2023);
- Developing software and hardware solutions to track types and quantities of food waste in professional kitchens (Winnow, a Romanian food waste management company) (Winnow, 2023);
- Developing an innovative building block made from captured carbon dioxide obtained from other industrial processes (Belgium) (European Investment Bank, 2023);
- Implementing water-saving solutions for use in homes, transportation, and hotels by purifying and reusing water within the same cycle (Orbital Systems, a Swedish company) (Orbital Systems, 2023).

Given the absence of universal solutions for transitioning to a circular economy, each country faces unique circular challenges and opportunities. The global circularity ratio (CGR) measures the state of the global economy and identifies the key levers for transitioning to global circularity, providing an annual global circular metric. This enabled the identification of disparities in the development of the circular economy among individual countries and sectors by measuring their current circularity status (Koval et al., 2023). In line with the above, the CGR grouped countries into three profiles to determine more effective development solutions for specific groups of countries (Table 2).

More in-depth research on the development of the circular economy can be examined using the example of European Union member states, which are classified as "shift" countries.

Sustainable development, which includes addressing challenges in the circular economy, is a priority in EU countries. The achievement of set goals by EU countries is planned to be realized through the establishment of societal activities and their interactions (Perga, 2017). Expedient assistance to the

economic development of the country due to the low wages of labor personnel, which is typical for a linear economy, is no longer relevant. Building an efficient and competitive country should be based on the development of human economic consciousness as a means of ensuring the stability of political systems in states.

Table 2. Directions of circular economy development within three country profiles. Source: based on (CGR, 2023).

Country profile	Build	Grow	Shift
Countries include:	countries of Africa south of the Sahara, some small island states, countries of Asia	countries in Latin America and North America, countries with transitional economies in Eastern Europe, the Caucasus, Central Asia, and most Asian countries	high-income countries in the global North, the Middle East, and the Australian continent
The largest countries in the group are:	(by population): India, Bangladesh, Ethiopia, Nigeria, Pakistan, Philippines	China, Indonesia, Brazil, Mexico, Vietnam, Egypt	United States of America, Japan, Argentina, European Union member countries
income level:	low	average	high
World population distribution, %:	46	37	17
Development direction:	dominance of agriculture; at the stage of constructing basic infrastructure	they are global production centres and the world's largest producers of agricultural products. They are characterized by a rapid level of industrialization and infrastructure development	they consume the majority of the world's resources and exceed the fair limits of planetary boundaries. They provide high standards of well-being for their population
Resource consumption levels:	they use less than a tenth of the world's materials	they use 51% of the resources and generate 41% of the emissions	they consume 31% of the resources and generate 43% of the emissions
Have a need for:	- economic system construction; - meeting basic needs (education, healthcare).	they are striving to uplift their population from poverty to a growing middle class	limiting their consumption in accordance with the resources of our planet
Directions of circular economy development:	- increasing well-being through technological advancements; - developing policies to support material and technical regenerative growth	- prioritizing pathways that promote material conservation and stabilize material usage (reducing consumption, promoting reuse); - increasing the quality of life for people to accelerate the development of national society	- focusing on reducing material extraction and usage (reducing quantities and promoting reuse) - abandoning excessive consumption of Earth's resources to sustain a relatively affluent and comfortable lifestyle

Unfortunately, the development of the circular economy in EU countries is not comprehensive; overall, their economy is still linear. For example, most metals and rare natural resources have a percentage of secondary processing at the end of their life cycle of around 1 (lithium, gallium, and neodymium) (Environment-People-Law, 2023).

Analysing the contribution of recycled materials to the demand for raw materials in EU countries, it is found that the highest relative weight in recycling in 2022 will be occupied by such types of raw materials as lead (83%), copper (55%), zinc (34%), aluminium (32%), iron and cast iron (31%), and molybdenum (30%) (Figure 2). Some types of raw materials, such as beryllium, dysprosium, gallium, and lithium, have not been reintroduced into the production system in the past nine years. The recycling rate at the end of the life cycle of certain types of raw materials in 2022, compared to 2016, remained unchanged: copper (55%), yttrium (31%), molybdenum (30%), praseodymium (10%), gypsum (1%), and tellurium (1%).

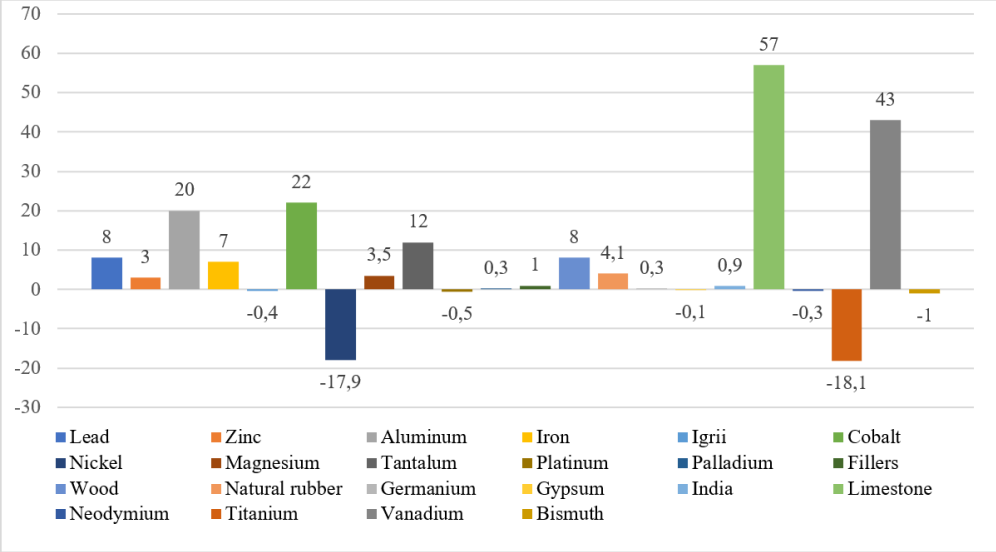


Figure 2. Dynamics of end-of-life recycling rates (EOL-RIR) of materials in EU countries during 2016-2022, in percentage. Source: based on European Investment Bank (2023).

In 2022, the EU countries have a demand for approximately 65% of raw materials, including boron, dysprosium, europium, gallium, germanium, indium, magnesium, molybdenum, neodymium, phosphorus, platinum, silicon, and yttrium. Analysing the self-sufficiency indicator, which shows the level of self-sufficiency from domestic production, exports, and imports, it is found that the EU countries are fully self-sufficient in limestone and vanadium (Figure 3). Over the past five years, from 2018 to 2022, the self-sufficiency level has increased for limestone (by 5.7 percentage points), fluorspar (by 11 percentage points), cobalt (by 16.4 percentage points), aluminium (by 1.2 percentage points), and natural graphite (by 0.7 percentage points). Conversely, copper (by 10.3 percentage points), iron (by 7.2 percentage points), and lithium (by 11.1 percentage points) experienced a decrease in their respective indicators.

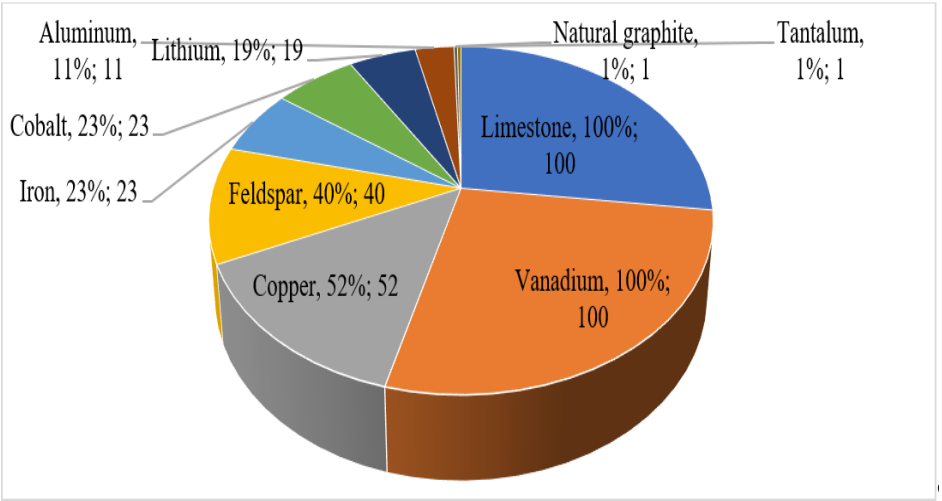
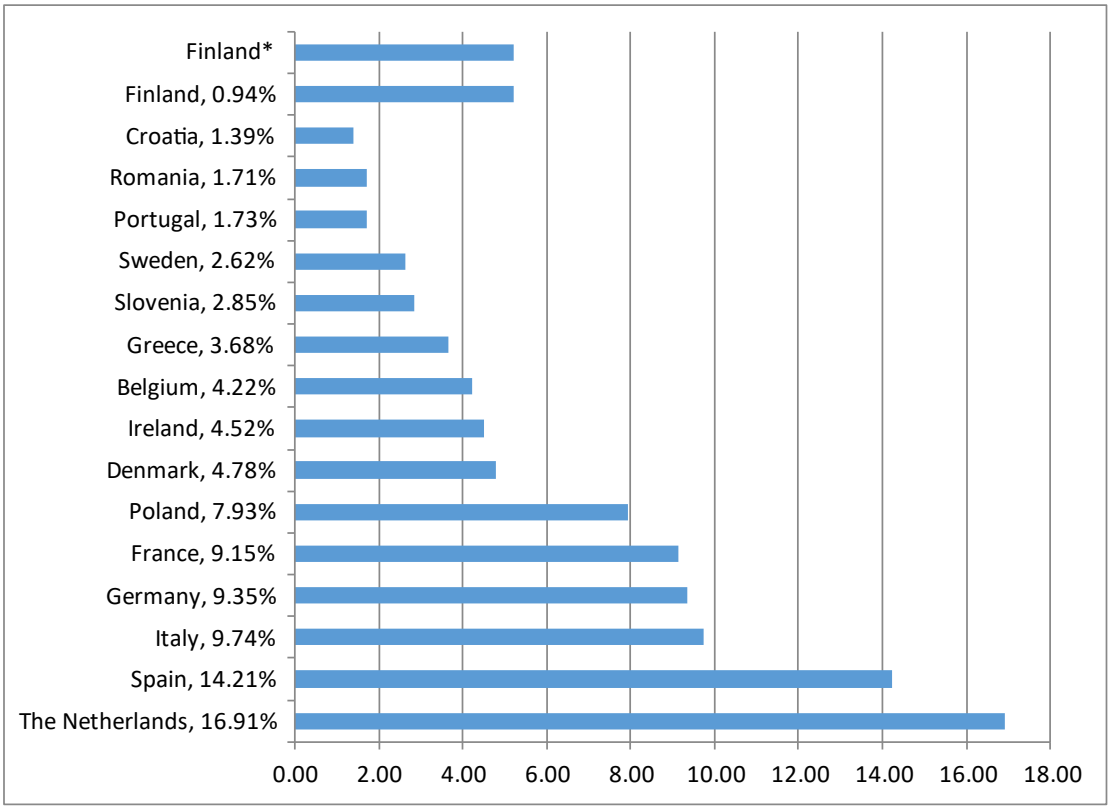


Figure 3. Self-sufficiency indicator of raw materials in EU countries in 2022. Source: based on European Investment Bank (2023).

Safe waste is considered a potentially important source of raw materials and valuable resources, which has led to an increase of 3.93% in the volumes of transboundary movement of recycled waste over the past decade. In 2021, EU countries sold the highest amount of secondary raw materials since 2012. Between 2019 and 2021 alone, the volumes of plastic, paper and cardboard, precious metals, iron and steel, copper, aluminium, and nickel transported between EU member states and across EU borders for trading purposes increased by approximately 613,203 tons. More than 50% of the total quantity of waste and scrap subject to recycling, as well as secondary raw materials (by-products), transported between EU member states (within the EU) and across its borders, are attributed to the Netherlands, Spain, Italy, Germany, France, Poland, Denmark, Ireland, Belgium, Greece, Slovenia, and Sweden (Figure 4).



Finland*, Lithuania, Austria, Latvia, Hungary, Cyprus, Bulgaria, Czech Republic, Estonia, Slovakia, Luxembourg, Malta - 5.21%

Figure 4. Share of trade volumes in secondary raw materials by EU countries in 2021. Source: based on European Investment Bank (2023).

Analysing the dynamics of the use of recycled and returned materials in the economy, thereby saving primary resource extraction. It was found that around 63% of EU countries had the lowest material circulation rates in 2021, specifically below 10% (Figure 5). In 9 countries, the corresponding indicator ranged from 10% to 20%. The Netherlands had the highest material circulation rate, indicating a high level of substitution of primary materials with secondary materials, thereby reducing the environmental impact of primary resource extraction, with a value of 33.8% in 2021. It is worth noting countries such as Estonia, Germany, the Czech Republic, Sweden, and Croatia, where a stable growth of the material circulation rate has been observed over the past five years.

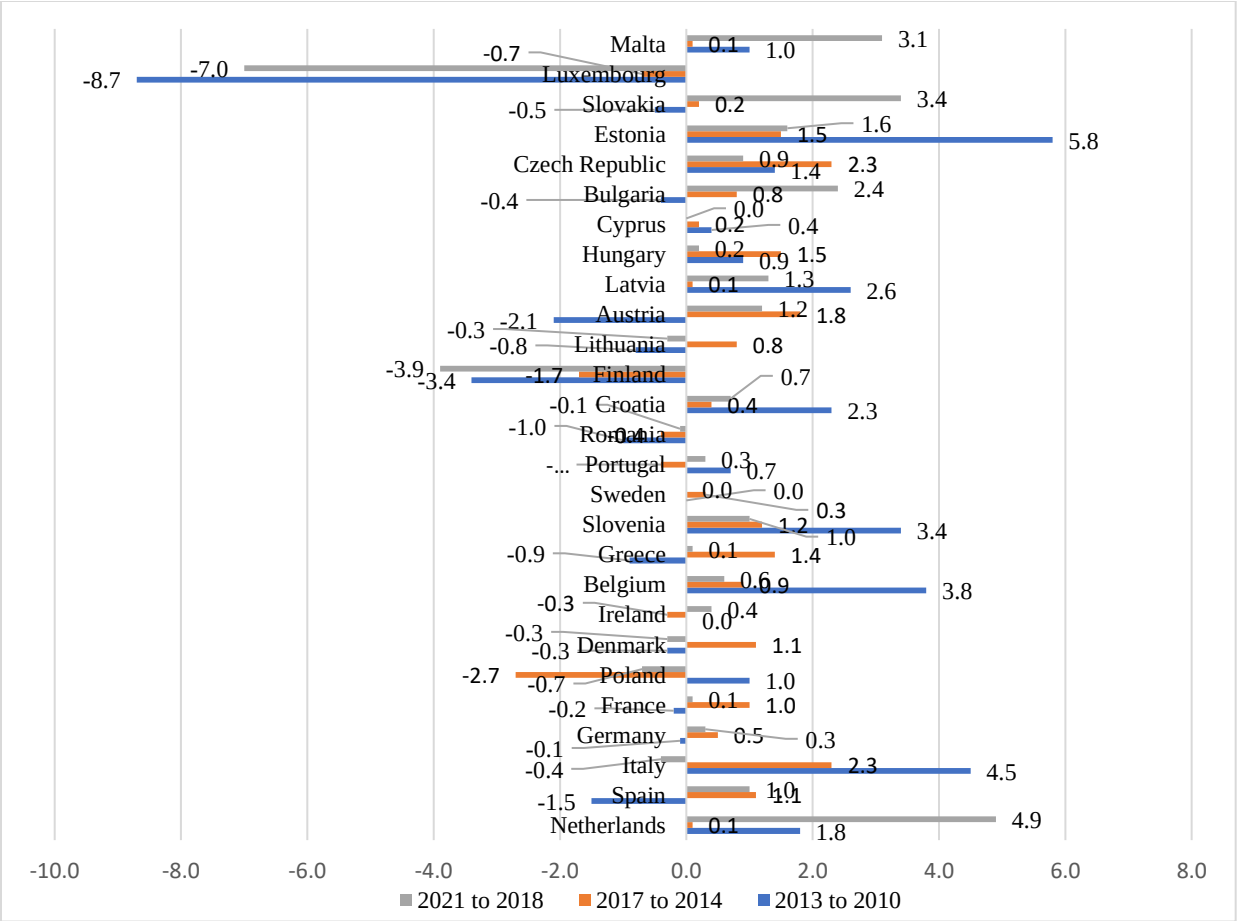


Figure 5. Dynamics of the material circulation rate in the EU countries during 2010-2021, in percentages compared to. Source: based on European Investment Bank (2023).

Ten EU countries have a circularity rate higher than 10%. These countries include the Netherlands, Belgium, France, Italy, Estonia, Germany, Austria, the Czech Republic, Malta, and Slovenia. In analysing other circularity indicators for EU countries, it has been observed that each country has different levels of achievement depending on the chosen circular economy development strategy (Figure 6). The research was conducted based on the average values for the following indicators during 2019-2021:

- *consumption indicator*, which assesses the environmental impact of EU countries' consumption across five areas: food, mobility, housing, electronics, and household goods;
- *gross investment in material goods and value added by factor costs* in three sectors: manufacturing, repair, and reuse;
- *household waste recycling rate*, which determines the share of recycled household waste in the total volume;
- *overall waste recycling rate, excluding major mineral waste*. The indicator covers hazardous and non-hazardous waste from all economic sectors and households, including secondary waste, but excluding most mineral waste;
- *number of people employed in circular economy sectors*, specifically in the sectors of manufacturing, repair, reuse, rental, and leasing.

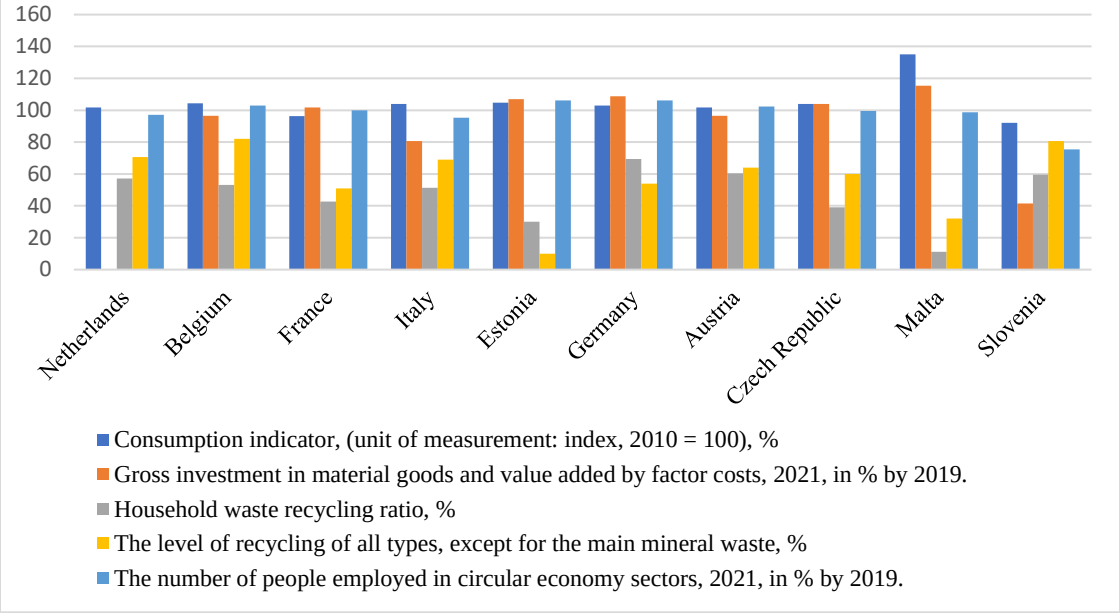


Figure 6. The average values of circulation indicators for EU countries with a circulation coefficient of more than 10% for the years 2019-2021. Source: Calculated by the author based on European Investment Bank (2023).

Table 3 presents a list of countries that outperform in terms of circulation indicators from 2019 to 2021, indicating that each country has its own circular economy development strategy adapted to its capabilities and strategic directions. Only a few countries with high circulation levels occupy high positions in other criteria assessing the circularity of their economies. Over the years, production in EU countries has been increasing and characterized by efficiency in resource utilization, but consumption levels are also raising. Therefore, the strategic direction of EU countries is the rationalization of goods and services consumption, aligning it with population needs, and eliminating excess.

Table 3. "The Top 3 countries" in terms of circulation indicators for 2019-2021 (based on European Investment Bank, 2023).

The name of the indicator	The name of the country	2021	2021 (+/-) compared to 2019	2021 (% compared to 2019)
Consumption indicator (unit of measure: index, 2010 = 100)	Malta	133	-8*	-
	Poland	120	+6*	-
	Bulgaria	115	-1*	-
Gross investment in tangible goods and value added at factor cost, million euros	United Kingdom	33722	+3528	111,7
	Germany	31507	+2537	108,8
	France	20405	+355	101,8
Coefficient of processing of household waste, %	Germany	71,1	+4,4*	-
	Slovenia	60,0	+0,8*	-
	Netherlands	57,8	+0,9*	-
Level of processing of all types of waste, excluding primary mineral waste, %	Belgium	87	+9*	-
	Slovenia	80	0*	-
	Netherlands	74	+2*	-
Number of individuals employed in circular economy sectors, male.	Germany	785297	+45675	106,2
	Italy	613339	-31242	95,2
	United Kingdom	590936	+17494	103,1

*percentage points

Despite the EU's unified policy for circular economy development, each country chooses its own path to achieve set goals. For example, Germany, with its developed industrial economy, has developed a foundation for the circular economy through material flows and material availability. The Netherlands focuses on material innovation and business models. Finland has created a national roadmap to transition to a circular economy. Scotland has initiated its work in the Circular Economy 100 Club to foster relationships and exchange innovations for circular economy development (Ecobusiness Group, 2021).

High levels of circular economy performance have been achieved by certain EU countries through the development of reliable recycling systems and innovation in closed-loop industries (Germany, France, the United Kingdom), as well as increased private investments and patents (France, Germany, Italy, the United Kingdom). However, the countries are leading the circularity rankings are not necessarily the most environmentally friendly. For example, waste incineration for energy generation, which minimizes landfilling but excludes material recycling and reuse processes, is practiced in some countries. The circularity rankings of certain countries are also affected by high levels of municipal and food waste (Politico, 2018).

Changing societal understanding from excessive to sustainable consumption is a key component of circular economy development (Soloviova et al., 2022). Shifting entrepreneurial activities towards rationalizing relationships with the environment will contribute to strengthening national directions for circular economy development and its sectors (Koval et al., 2021; Latysheva et al., 2021; Ostapenko et al., 2020).

4. Discussion

The main factor influencing the effectiveness of circular economy development is society, which requires assistance in rethinking its relationship with the environment, understanding the cause-and-effect relationship of excessive and inefficient use of natural resources, the consequences of biodiversity loss, and the irreversible processes resulting from the continuation of unsustainable behaviour towards the environment.

By analysing circularity indicators in the example of European Union countries, it has been found that the final level of circular economy development in a specific country can only be determined by taking into account its national peculiarities and development priorities, as well as the implementation of circular economy principles.

The transition to a circular economy is the result of the interactions between individuals, families, society, institutions, economic sectors, regions, and countries. The foundation of humanity is awareness, which leads to the formation of new and the transformation of existing societal behavioural patterns. The transition to a circular economy is a progressive mental structure that ensures the preservation of the balance between humans and nature, the rational use of natural resources, and the elimination of excessive human activity.

Circularity brings new adjustments to the economic-production sphere, such as reducing production, developing repair, recycling, and reprofiling industries, etc. There is a shift in humanity's thinking towards priorities for regeneration, extending the lifespan of products, producing with a lower carbon footprint, and low resource intensity. The circular economy should become the basis of society's worldview and be realized through all its activities.

Cooperation plays a significant role in the strategic development of humanity. It reduces costs and time spent implementing innovations. Therefore, it is important to build the infrastructure for the circular economy and facilitate the interaction of its elements within a country or among multiple countries.

An example of cooperation in circular economy development is the Circle lab Amsterdam smart city (Amsterdam Smart City, 2023), an open innovation platform that promotes collaboration between companies, policymakers, etc., created by the social enterprise Circle Economy, which aims to mobilize a global community of cities, businesses, and citizens to address universal challenges through the exploration, analysis, and implementation of circular business models, strategies, and solutions. Another example of mutual development towards a circular economy is the Amsterdam Circular Economy Strategy 2020–2050, which aims to significantly reduce the use of virgin resources through the joint efforts of the Dutch government and the European Union (Amsterdam Smart City, 2023).

5. Impact

The effective development of the circular economy entails a holistic approach towards rationalizing the use of natural resources. Potential consequences of a circular economy include the creation of new jobs, efficient resource management, combating inequality and social crises, and sustainable development of world economies.

Despite having a unified European "green" policy, each country has different focus areas and speed of implementation. Undoubtedly, the Netherlands is the leader in circular economy development, aiming to become a country fully based on the circular economy by 2050. Cyprus, Malta, Bulgaria, and Romania have the slowest pace of circular economy development, with only a few projects implemented in the field of eco-innovation, efficient resource use, energy efficiency, or renewable energy sources in recent years. These countries require investment incentives and proposals for changing their political orientations towards activating circular economy development.

A study was conducted on the extraction of the main factors influencing the development of the circular economy in countries. Using clustering in 27 European countries, the interdependence between certain circularity indicators was analysed. Accordingly, each country was ranked based on a specific circularity indicator, allowing us to form an understanding of the following relationship: A country's ranking for a particular circularity indicator from 1 to 10 corresponds to high levels of development; countries ranked from 11 to 20 have medium levels, and countries ranked from 21 to 27 have low levels.

Four circularity indicators were chosen for clustering:

- Resource productivity, which measures the total quantity of materials directly used by the economy.
- Recycling level of all waste, excluding major mineral waste.
- Private investments and gross value added associated with circular economy sectors.
- Consumption footprint (consumption indicator), which assesses the environmental impact of EU consumption and member states by combining data on consumption intensity and the environmental impact of representative products.

As a result of the clustering based on the "Resource Productivity" indicator (Table 4), it was found that countries with a high level of resource productivity, predominantly have medium and low levels of waste recycling and investments, and mainly have medium and low levels of consumption footprint.

Conversely, countries with a low level of resource productivity, predominantly have medium and low levels of waste recycling and investments, and mainly have high and medium levels of consumption

footprint. Therefore, a conclusion can be drawn regarding the direct correlation between overproduction's impact on environmental pollution and the need to improve innovative processes for further development of the circular economy.

Table 4. Grouping of European countries based on the rating of circular economy indicators "Resource Productivity" and "Consumption Footprint"*. Source: based on (European Investment Bank, 2023).

Grouping of countries based on the "Resource Productivity" rating						Grouping of countries based on the "Consumption Footprint" rating				
Country name	Country rating by indicators				Level of development	Country name	Country ranking by indicators			
	Resource productivity ranking	Waste recycling rate	Investments in the circular economy	Consumption footprint			Consumer footprint	Resource productivity	Waste recycling rate	Investments in the circular economy
Netherlands	1	3	5	17	**High**	Malta	1	9	21	26
Luxembourg	2	5	18	6		Poland	2	23	14	9
Ireland	3	-	11	25		Bulgaria	3	27	22	22
Italy	4	4	4	12		Denmark	4	11	7	10
France	5	16	3	19		Croatia	5	18	9	21
Belgium	6	1	6	21		Luxembourg	6	2	5	18
Germany	7	12	2	23		Portugal	7	20	19	13
Spain	8	15	7	11		Romania	8	26	20	14
Malta	9	21	26	1		Czech Republic	9	19	11	16
Austria	10	8	8	15		Lithuania	10	24	26	20
Denmark	11	7	10	4	**Medium**	Spain	11	8	15	7
Sweden	12	-	12	16		Italy	12	4	4	4
Slovenia	13	2	27	27		Estonia	13	25	23	24
Greece	14	-	26	24		Cyprus	14	16	17	28
Slovakia	15	10	19	20		Austria	15	10	8	8
Cyprus	16	17	28	14		Sweden	16	12	-	12
Finland	17	18	17	22		Netherlands	17	1	3	5
Croatia	18	9	21	5		Hungary	18	22	13	15
Czech Republic	19	11	16	9		France	19	5	16	3
Portugal	20	19	13	7		Slovakia	20	15	10	19
Latvia	21	6	23	26	**Low**	Belgium	21	6	1	6
Hungary	22	13	15	18		Finland	22	17	18	17
Poland	23	14	9	2		Germany	23	7	12	2
Lithuania	24	26	20	10		Greece	24	14	-	26
Estonia	25	23	24	13		Ireland	25	3	-	11
Romania	26	20	14	8		Latvia	26	21	6	23
Bulgaria	27	22	22	3		Slovenia	27	13	2	27

*The rating was based on the indicators of the year 2021

According to the results of country grouping based on the "Consumption Footprint" indicator (Table 5), it was found that 30% of countries with a high level of consumption indicator also have a high level of waste processing and, consequently, high or medium levels of resource productivity and investments. There are countries with a high level of consumption footprint regardless of high levels of investments (e.g., Poland), as well as countries with high levels of waste processing but high resource productivity (e.g., Luxembourg), indicating the negative environmental impact of overproduction and excesses in commodity production and material use. Confirmation of the above can be seen in the analysis of the corresponding grouping of countries with average and low levels, where the percentage of countries with high resource productivity is higher than in high-level countries.

Examining the grouping of European countries based on the "Investments in the Circular Economy" rating (Table 5), it was found that countries with high levels of investments in circular economy development also exhibit high indicators of resource productivity and material processing. However, only about 20% of them have a low level of consumption footprint, indicating a lack of sufficient eco-innovations.

Table 5. Grouping of European countries based on the rating of circular economy indicators "Investments in the Circular Economy" and "Waste Recycling Level"*. Source: compiled by the author based on (European Investment Bank, 2023).

Grouping of countries based on the "Investments in Circular Economy" rating						Grouping of countries based on the "Waste Recycling Level" rating				
Country name	Country rankings by indicators				Level of development	Country name	Country rankings by indicators			
	Investments in the circular economy	Resource productivity	Level of waste recycling	Ecological footprint			Level of waste recycling	Resource productivity	Investments in the circular economy	Ecological footprint
Germany	2	7	12	23	**High**	Belgium	1	6	6	21
France	3	5	16	19		Slovenia	2	13	28	27
Italy	4	4	4	12		Netherlands	3	1	5	17
Netherlands	5	1	3	17		Italy	4	4	4	12
Belgium	6	6	1	21		Luxembourg	5	2	18	6
Spain	7	8	15	11		Latvia	6	21	23	26
Austria	8	10	8	15		Denmark	7	11	10	4
Poland	9	23	14	2		Austria	8	10	8	15
Denmark	10	11	7	4		Croatia	9	18	21	5
Ireland	11	3	-	25		Slovakia	10	15	19	20
Sweden	12	12	-	16	**Medium**	Czech Republic	11	19	16	9
Portugal	13	20	19	7		Germany	12	7	2	23
Romania	14	26	20	8		Hungary	13	22	15	18
Hungary	15	22	13	18		Poland	14	23	9	2
Czech Republic	16	19	11	9		Spain	15	8	7	11
Finland	17	17	18	22		France	16	5	3	19
Luxembourg	18	2	5	6		Cyprus	17	16	28	14
Slovakia	19	15	10	20		Finland	18	17	17	22
Lithuania	20	24	26	10		Portugal	19	20	13	7
Croatia	21	18	9	5		Romania	20	26	14	8
Bulgaria	22	27	22	3	**Low**	Malta	21	9	26	1
Latvia	23	21	6	26		Bulgaria	22	27	22	3
Estonia	24	25	23	13		Estonia	23	25	24	13
Greece	25	14	-	24		Ireland	-	3	11	25
Malta	26	9	21	1		Greece	-	14	26	24
Slovenia	27	13	2	27		Lithuania	26	24	20	10
Cyprus	28	16	17	14		Sweden	-	12	12	16

* The ranking was based on indicators from the year 2021

Groups of countries with a high level of waste processing are mainly characterized by high or moderate levels of resource productivity, with varying levels of investment in circular economy development. Approximately 60% of these countries have high or moderate levels of material footprint. A similar situation is observed as in previous groupings: countries with moderate and low levels of waste processing exhibit average to low levels of resource productivity and have better material footprint indicators.

Therefore, the results of the grouping reveal that the main influential factor in the development of a circular economy is social interactions and national peculiarities of countries, which determine the level of material use efficiency directly impacting environmental protection and preservation.

The alignment of societal vision regarding the directions of circular economy development is a crucial condition for accelerating the adaptation of the corresponding process to specific implementation conditions. This allows considering the possibilities of circular economy development beyond the formal relations of society and social perception, enhancing initiative and promoting the inclusion of new ideas, which will continuously and gradually expand the boundaries of circular economy feasibility.

Thus, the analysis of circularity indicators in EU countries reveals that the results are relative. To draw definitive conclusions regarding the circularity level of a specific country, it is necessary to consider its economic performance in the context of national characteristics and development priorities. By examining the development directions of countries across all profiles towards building a circular economy, the fundamental positions applicable to each have been identified (Figure 7).

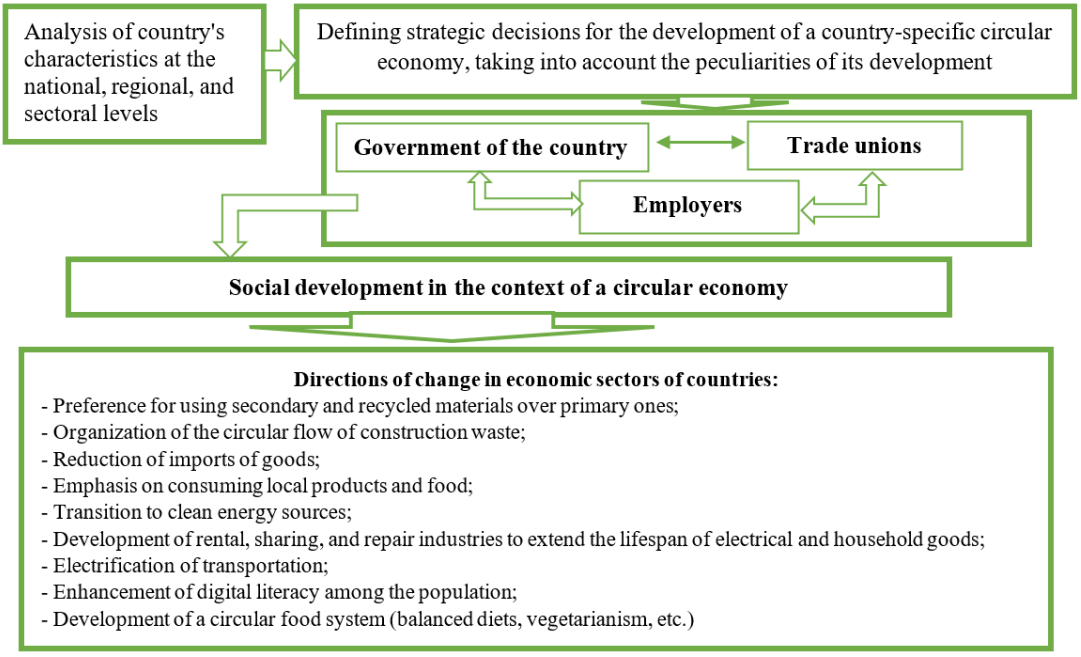


Figure 7. Key directions of circular economy development in countries.

6. Conclusions

The main strategic direction for development is addressing global societal issues related to environmental pollution, resource depletion, and climate change. The contemporary international economy is characterized by a shift in development priorities among countries, moving from economic enrichment to a rational combination of strategic development directions: efficient management while conserving natural resources and protecting the environment.

The implementation of elements of the circular economy is carried out by the majority of countries worldwide at different levels of development. The principles of circular economic development are already embedded in the economic plans of countries with lower levels of development. The key direction

of political changes aimed at increasing the level of environmental sustainability in countries should primarily focus on raising society's awareness of the possible consequences of their irrational attitudes and behaviours towards natural resources. Analysing the directions of circular economy development in countries with different economic development levels, the fundamental positions that are specific to each country encompass various sectors such as construction, energy, education, food, services, and import reduction.

The policy for the development of the circular economy of EU countries in the direction of sustainable development and rational use of natural resources should be aimed at encouraging industries to develop more durable products with repair and recycling capabilities, setting goals for reducing resource consumption and increasing the level of efficiency of their use; development of circular economy infrastructure; promotion of public awareness of the results of the relationship between society and nature; implementation of incentives for the development of circular economy business models; investing in the development of emerging technologies that support circularity; and improving the methodology for assessing the level of economic circulation.

Overall, considering all countries worldwide, it can be asserted that the circular economy has already surpassed its initial stage of inception and is now at a stage of development. Regardless of the performance results, most countries strive to operate based on circular economy principles. Analysing the indicators of circularity among EU member states, it is revealed that in only 36.7% of the researched raw material types, there is an increase in their reuse level in production, whereas in 60% of the researched raw material types, the corresponding level has either decreased or remained unchanged. The analysis of circularity indicators among EU countries shows that each country has its own circular economy development strategy adapted to its capabilities and strategic development directions. Even within a single country, there is no consistently high value for several indicators, indicating an individual approach to choosing the direction of conserving primary raw material extraction, thus aiming to protect the environment, promote material reuse, etc.

In the process of analysing the strategic tasks for the development of a closed-loop economy by countries worldwide, it is evident that the development of a circular economy is directly dependent on societal perception and the direction of their lifestyle. Therefore, the main focus when planning economies based on circular principles is to organize changes in human behavior, such as preferring local goods and services over imported ones, changing dietary structures, modes of transportation, and work organization. These societal changes will facilitate the development of relevant closed-loop economy sectors, including rental, processing, and disposal.

Conflict of Interest
The authors confirm that there is no conflict of interest to declare for this publication.

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References

Adams, K.T., Osmani, M., Thorpe, T., & Thornback, J. (2017). Circular economy in construction: Current awareness, challenges and enablers. *Waste and Resource Management*, *170*(1), 15-24. https://doi.org/10.1680/jwarm.16.00011.

Amsterdam Smart City. (2023). https://amsterdamsmartcity.com.

Apollon, W., Rusyn, I., González-Gamboa, N., Kuleshova, T., Luna-Maldonado, A.I., Vidales-Contreras, J.A., & Kamaraj, S.K. (2022). Improvement of zero waste sustainable recovery using microbial energy generation systems: A comprehensive review. *Science of the Total Environment*, *817*, 153055. https://doi.org/10.1016/j.scitotenv.2022.153055.

Ayeleru, O.O., Okonta, F.N., & Ntuli, F. (2018). Municipal solid waste generation and characterization in the City of Johannesburg: A pathway for the implementation of zero waste. *Waste Management*, *79*, 87-97. https://doi.org/10.1016/j.wasman.2018.07.026.

Bauwens, T. (2021). Are the circular economy and economic growth compatible? A case for post-growth circularity. *Resources, Conservation and Recycling*, *175*, 105852. https://doi.org/10.1016/j.resconrec.2021.105852.

Bocken, N.M.P., Olivetti, E.A., Cullen, J.M., Potting, J., & Lifset, R. (2017). Taking the circularity to the next level: A special issue on the circular economy. *Journal of Industrial Ecology*, *21*(3), 476-482. https://doi.org/10.1111/jiec.12606.

Borealis, (2023). https://www.borealisgroup.com.

Boulding, K. (1966). The economics of the coming spaceship earth. In: Jarrett, H. (ed.) *Environmental Quality in a Growing Economy* (3-14), Resources for the Future/Johns Hopkins University Press, Baltimore.

Calisto Friant, M., Vermeulen, W.J.V., & Salomone, R. (2021). Analysing european union circular economy policies: Words versus actions. *Sustainable Production and Consumption*, *27*, 337-353. https://doi.org/10.1016/j.spc.2020.11.001.

Centobelli, P., Cerchione, R., Chiaroni, D., Del Vecchio, P., & Urbinati, A. (2020). Designing business models in circular economy: A systematic literature review and research agenda. *Business Strategy and the Environment*, *29*(4), 1734-1749. https://doi.org/10.1002/bse.2466.

CGR. (2023). https://www.circularity-gap.world/.

Domenech, T., & Bahn-Walkowiak, B. (2019). Transition towards a resource efficient circular economy in europe: Policy lessons from the EU and the member states, *Ecological Economics*, *155*, 7-19. https://doi.org/10.1016/j.ecolecon.2017.11.001.

Ecobusiness Group. (2021). The experience of European countries in the transition to a circular economy. https://ecolog-ua.com/news/dosvid-krayin-yevropy-v-perehodi-do-cyrkulyarnoyi-ekonomiky

Environment-People-Law. (2023). Circular economy: rapid steps are needed to achieve the EU's circular economy goals. http://epl.org.ua/announces/krugova-ekonomika-potribni-shvydshi-kroky-dlya-dosyagnennya-tsilej-yes-shhodo-formuvannya-tsyrkulyarnoyi-ekonomiky/

European Commission. (2023). https://commission.europa.eu.

European Investment Bank. (2023). Circular economy: Overview. https://www.eib.org.

Gaddy, B.E., Sivaram, V., Jones, T.B., & Wayman, L. (2017). Venture capital and cleantech: The wrong model for energy innovation. *Energy Policy*, *102*, 385 395. https://doi.org/10.1016/j.enpol.2016.12.035.

Geissdoerfer, M., Morioka, S.N., de Carvalho, M.M., & Evans, S. (2018). Business models and supply chains for the circular economy. *Journal of Cleaner Production*, *190*, 712-721. https://doi.org/10.1016/j.jclepro.2018.04.159.

Grieze E., & Miķelsone E. (2021). Biomimicry element application in the interior design product development. *Economics Ecology Socium*, *5*(2), 59-70. https://doi.org/10.31520/2616-7107/2021.5.2-7.

Haney A., Krestyaninova O., & Love Ch. (2019). The circular economy boundaries and bridges. Oxford, Said Business School, University of Oxford. https://www.sbs.ox.ac.uk/sites/default/files/2019-09/the-circular-economy.pdf.

Horbal, N.I., & Lomaha, Y.R. (2022). Circular economy - The basis of sustainable enterprise development. *Journal of Lviv Polytechnic National University. Series of Economics and Management Issues*, *6*(1), 9-24. https://doi.org/10.23939/semi2022.01.009.

Kirchherr, J. (2022). Circular economy and growth: A critical review of "post-growth" circularity and a plea for a circular economy that grows. *Resources, Conservation, and Recycling*, *179*, 106033. https://doi.org/10.1016/j.resconrec.2021.106033.

Korhonen, J., Nuur, C., Feldmann, A., & Birkie, S.E. (2018). Circular economy as an essentially contested concept. *Journal of Cleaner Production*, *175*, 544-552. https://doi.org/10.1016/j.jclepro.2017.12.111.

Koval, V., Kryshtal, H., Udovychenko, V., Soloviova, O., Froter, O., Kokorina, V., & Veretin, L. (2023). Review of mineral resource management in a circular economy infrastructure. *Mining of Mineral Deposits*, *17*(2), 61-70. https://doi.org/10.33271/mining17.02.061.

Koval, V., Mikhno, I., Udovychenko, I., Gordiichuk, Y., & Kalina, I. (2021). Sustainable natural resource management to ensure strategic environmental development. *TEM Journal*, *10*(3), 1022-1030. https://doi.org/10.18421/tem103-03.

Lacy, P., Long, J., & Spindler, W. (2020). *The circular economy handbook: Realizing the circular advantage*. Palgrave Macmillan, UK. https://doi.org/10.1057/978-1-349-95968-6.

Latysheva, O., Rovenska, V., Smyrnova, I., Nitsenko, V., Balezentis, T., & Streimikiene, D. (2021). Management of the sustainable development of machine-building enterprises: A sustainable development space approach. *Journal of Enterprise Information Management*, *34*(1), 328-342. https://doi.org/10.1108/jeim-12-2019-0419.

Liu, Y., & Bai, Y. (2014). An exploration of firms' awareness and behavior of developing circular economy: Empirical research in China. *Resources, Conservation, and Recycling*, *87*, 145-152. https://doi.org/10.1016/j.resconrec.2014.04.002.

Masi, D., Kumar, V., Garza-Reyes, J.A., & Godsell, J. (2018). Towards a more circular economy: Exploring the awareness, practices, and barriers from a focal firm perspective. *Production Planning & Control*, *29*(6), 539-550. https://doi.org/10.1080/09537287.2018.1449246.

Milios, L. (2018). Advancing to a circular economy: Three essential ingredients for a comprehensive policy mix. *Sustainability Science*, *13*(3), 861-878. https://doi.org/10.1007/s11625-017-0502-9.

Orbital Systems. (2023). https://www.orbital-systems.com/.

Ormazabal, M., Prieto-Sandoval, V., Puga-Leal, R., & Jaca, C. (2018). Circular economy in Spanish SMEs: Challenges and opportunities. *Journal of Cleaner Production*, *185*, 157-167. https://doi.org/10.1016/j.jclepro.2018.03.031.

Ostapenko, R., Herasymenko, Y., Nitsenko, V., Koliadenko, S., Balezentis, T., & Streimikiene, D. (2020). Analysis of production and sales of organic products in Ukrainian agricultural enterprises. *Sustainability*, *12*(8), 3416. https://doi.org/10.3390/su12083416.

PeelPioneers. (2023). https://peelpioneers.nl/home-en.

Perga, T. (2017). Sustainable development in new EU members. European historical studies, 6, 48-63.

Politico. (2018). Ranking how EU countries do with the circular economy. https://www.politico.eu/article/ranking-how-eu-countries-do-with-the-circular-economy/.

Potapenko, V.G. (2012). *Strategic priorities of the safe development of Ukraine on the basis of the "green economy"*. K.: NISD.

Prokayeva, A. (2021). *Modern waste management according to the principles of circular economy*. Course guide ZWA deep level.

Prolupin. (2023). https://www.eitfood.eu/community/startups/prolupin.

Renewcell. (2023). https://www.renewcell.com/en.

Saviola Holding. (2023). https://www.grupposaviola.com.

Schröder, P., Lemille, A., & Desmond, P. (2020). Making the circular economy work for human development. *Resources, Conservation, and Recycling, 156*, 104686. https://doi.org/10.1016/j.resconrec.2020.104686.

Shubaly, O., Khomytskyi, V. & Moshchych, S. (2023). Methodical provision of the analysis and assessment of the development of the circular economy in the EU. *Economic Forum*, *1*(1), 18-26. https://doi.org/10.36910/6775-2308-8559-2023-1-3.

Soloviova, O., Krasnyak O., Cherkaska, V., & Revkova, A. (2022). Strategic development of international corporate social responsibility in agribusiness. *Economics Ecology Socium*, *6*(4), 51-64. https://doi.org/10.31520/2616-7107/2022.6.4-5.

Watkins E., & Meysner A. (2022). European circular economy policy landscape overview. Report. Institute for European Environmental Policy.

Winnow. (2023). https://www.winnowsolutions.com/.

Xue, B., Chen, X.P., Geng, Y., Guo, X.J., Lu, C.P., Zhang, Z.L., & Lu, C.Y. (2010). Survey of officials' awareness on circular economy development in China: Based on municipal and county level. *Resources, Conservation, and Recycling*, *54*(12), 1296-1302. https://doi.org/10.1016/j.resconrec.2010.05.010.

Zaman, A.U. (2015). A comprehensive review of the development of zero waste management: Lessons learned and guidelines. *Journal of Cleaner Production*, *91*, 12-25. https://doi.org/10.1016/j.jclepro.2014.12.013.