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An Analysis of the Circular Economy in Europe through Comparative Research Employing The CRITIC-Based MAUT and COPRAS Methods

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ABSTRACT

Purpose: The circular economy is an approach to sustainability that takes into account both the economic and environmental benefits of repurposing waste or underutilized inert assets into new, useable products or services. The research aims to present a comparative analysis of EU countries with multi-criteria decision-making methods using various indicators covering many topics, including emphasis on recycling, use of circular materials, material efficiency and collective management of waste.

Methodology: The research aims to determine the weights through the application of the CRITIC method. It is gathered in 22 sub-indicators under three main categories, including sustainable resource management, social behaviour, and business operations, so as to assess effectiveness with regard to this notion while comparing nations. Additionally, every nation in the EU that has indicator data is assessed employing cluster analysis, a method of data mining, in addition to multi-criteria decision-making techniques like MAUT and COPRAS.

Findings: Based on the assessments of nations, Denmark, Luxembourg, Finland, Austria, Sweden, the United Kingdom, and Germany exhibit a favourable and noteworthy distinction from other nations.

Originality: This study offers the opportunity to make comparisons with a multi-criteria decision-making approach when it comes to environmental and circular economy goals.

Keywords: Circular Economy, Sustainable Environment, European Green Deal, MCDM, CRITIC, MAUT, COPRAS, Cluster Analysis.

***JEL Codes*:** D81, Q53, Q56, Q58.

CRITIC Tabanlı MAUT ve COPRAS Yöntemlerini Kullanan Karşılaştırmalı Araştırma ile Avrupa'da Döngüsel Ekonominin Analizi

ÖZET

Amaç: Döngüsel ekonomi, atıkların veya yeterince kullanılmayan atıl varlıkların yeni, kullanılabilir ürün veya hizmetlere dönüştürülmesinin hem ekonomik hem de çevresel faydalarını dikkate alan bir sürdürülebilirlik yaklaşımıdır. Araştırmada, geri dönüşüm vurgusu, döngüsel malzeme kullanımı, malzeme verimliliği ve atıkların kolektif yönetimi dâhil olmak üzere birçok konuyu içeren çeşitli göstergeler kullanarak çok kriterli karar verme yöntemleriyle AB ülkelerinin karşılaştırmalı analizinin sunulması hedeflenmektedir.

Yöntem: Araştırma, CRITIC yönteminin uygulanmasıyla ağırlıkların belirlenmesini amaçlamaktadır. Ülkeleri karşılaştırırken bu kavrama ilişkin etkinliği değerlendirmek amacıyla sürdürülebilir kaynak yönetimi, sosyal davranış ve iş operasyonları olmak üzere üç ana kategori altında 22 alt göstergede toplanmıştır. Ayrıca AB'de gösterge verisi olan her ülke, MAUT ve COPRAS gibi çok kriterli karar verme tekniklerinin yanı sıra veri madenciliği yöntemi olan kümeleme analizi kullanılarak değerlendirilmektedir.

Bulgular: Ülkelerin değerlendirmelerine göre Danimarka, Lüksemburg, Finlandiya, Avusturya, İsveç, Birleşik Krallık ve Almanya diğer ülkelerden olumlu ve dikkate değer bir farklılık sergilemektedir.

Özgünlük: Bu çalışma, çevresel ve döngüsel ekonomi hedefleri söz konusu olduğunda çok kriterli karar verme yaklaşımı ile karşılaştırma yapabilme imkânı sunmaktadır.

Anahtar Kelimeler: Döngüsel Ekonomi, Sürdürülebilir çevre, Avrupa Yeşil Anlaşması, ÇKKV, CRITIC, MAUT, COPRAS, Kümeleme Analizi.

JEL Kodları: D81, Q53, Q56, Q58.

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1. INTRODUCTION

The idea of a circular economy is based on the principle that resources should be maintained within the economic system for as long as is practically possible. In this type of economy, materials that have been through their entire lifecycle, from the stage of production to the stage of disposal, are brought back into the economic system as inputs. The existing production and consumption system clearly puts a heavy burden on our planet. Experts estimate that in order to maintain our current level of life, three Earths would be required if the current pace of population increase continues and the world's population hits 9.6 billion in 2050 (Saad et al., 2021). Approximately 1,3 billion tonnes of food costing one trillion dollars are lost every year as a result of households or enterprises harvesting, storing, or transporting food improperly. Over one billion people still do not have oppurtunity to reach safe freshwater in spite of this (Liu et al., 2022). About 2.5% of the world's clean water is stored in the Antarctic, the Arctic, and glaciers. Only 0.5 percent of Earth's surface supplies all of humanity's ecological and freshwater needs (Kilemo, 2022). As a result, despite technological advancements that have increased efficiency, energy consumption has been on the rise. The global industrialized economy, which is based on nonrenewable crude oil resources, may have achieved its maximum output. Despite rising worry over climate change's effects, a workable fossil fuel substitute has not yet been created (Tetteh et al., 2021; Yuan et al., 2022). Reduced resource usage, deterioration, and pollution, along with improved quality of life for all community members, are all goals of sustainable consumption and production. Increasing our economic production is important, but we also need to find ways to cut down on waste. Degradation of the natural world also slows down development and growth (Aguiñaga and Leal, 2021: 88; Khaw-ngern et al., 2021).

In the framework of the existing economic system, an attempt is made to assess the increase in the overall welfare based on how much people consume. More consumption is defined as more welfare and development. In addition, many people believe that improving the present productive capacities of economies will lead to an increase in the general well-being of both individuals and countries (Borowski and Patuk, 2021; Mies and Gold, 2021). Many issues, such as endangering natural life, social life, and future generations, are caused by the reckless use of finite resources, the presence of a system built on unending consumption, and the careless waste management during and after production. Global warming, ozone depletion, water and air pollution, loss of biodiversity, and deforestation are only some of the problems caused by these variables that threaten human and environmental well-being. When a product's whole life cycle—from manufacture to consumption—is taken into account, several unfavourable outcomes are evident, including air and water pollution, the loss of arable land, and greenhouse gas emissions (Gautam and Agrawal, 2021; Rather et al., 2022). The aforementioned negative consequences may be mitigated with the help of planned improvements in the manufacturing, supplying, and consuming triad. The "Responsible Consumption and Production Targets" under the "2030 Sustainable Development Goals" agenda are the consequence of a wide range of national and international efforts. In this respect, the OECD offers the following definition of sustainable consumption, but there are many more. The usage of goods and services that raise people's level of living and enable them to satisfy their most basic requirements without endangering the capacity of future generations to do the same is known as sustainable consumption. It is achieved by lowering the quantity of waste and pollution generated, as well as the amount of energy, water, and other resources used at each step of the product's life cycle (Pineiro-Villaverde and García-Álvarez, 2020; Yagi and Kokubu, 2020).

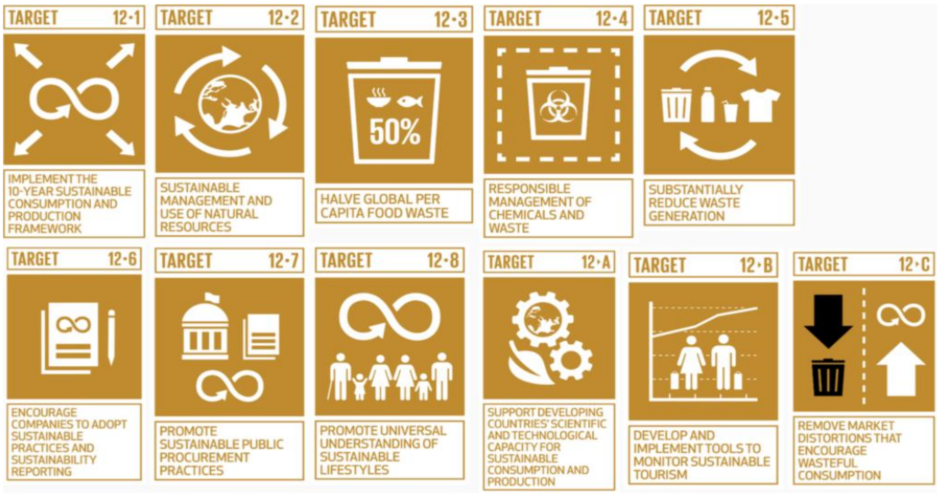

Figure 1. Goal 12: Encourage the use of environmentally friendly manufacturing and use strategies (Majeed, 2021)

Sub-goals include lowering overall consumption, increasing public understanding of the costs of wasteful consumption, and fostering greener methods of manufacturing. Summary of these aims is shown in Figure 1 (Majeed, 2021). Sustainable consumption goals aim to raise living standards of individuals without causing the carrying capacity of earth to be exceeded, and they also aim to build an infrastructure that will allow coming generations to have similar benefits (Bengtsson et al., 2018).

Improved resource productivity, cleaner production, and pollution management have been important goals of contemporary environmental strategies. After the turn of the century, this problem grew to include a wider range of concerns, such as how to deal with items at the end of their useful lives and how to ensure that producers properly collected consumer garbage. Some progress has been made in lowering the need for raw materials. Also, total consumption have risen with population and prosperity, thus it has damped the product-based productivity enhancements. It has been understood that if the consumption rate and consumption behavior aren't addressed, it would be very hard to realize the goal of sustainable development (Bengtsson et al., 2018; Mont and Plepys, 2008).

The concept of a circular economy has developed and gained popularity in this circumstances. The concept of a "circular economy" is becoming more commonplace. Present visions for a sustainable and durable development also include basic principles of circular economy model. The goal of this design philosophy is to maximize the number of times a product or material is reused, recycled, remanufactured, or recovered. As a result, items and the sources they were made from last longer, and fewer harmful byproducts and less greenhouse gas emissions are produced (Sharma et al., 2021).

The transition to a circular economy is high on the policy agenda of many organizations and institutions:

- The Climate Agreement of Paris
- United Nations Sustainable Development Objectives (SDG 12, 11, 9 and 13)
- Action Plan for a Circular Economy and the European Green Deal
- Durban Recommendations for Africa in 2019
- Plan for China's Circular Economy during the Next 5 Years
- Strategy for a circular economy in Latin American nations

Sustainable development that benefits present and future generations in terms of the environment, economy and social justice is further facilitated by the circular economy at all scales, from individual products and companies to the regional economy and global community. These advancements have made feasible by progressive company concepts and conscientious customers (Kirchherr, et al., 2017). The circular economy model (bottom) and linear economy model (top) are shown in Figure 2.

Figure 2. Phases of linear and circular systems (European Commission, 2014: 5)

Significantly, circular strategies, technologies, and transition enterprises aim beyond conventional economic paradigms. Sustainability-aligned circular economy concepts give the following advantages: Reducing greenhouse gas emissions: If circular economy ideas are implemented throughout the steel, aluminum, cement, food, and plastic industries, 9.3 billion tonnes of CO_2 might be avoided by 2050. Preserving long-term biodiversity: a 50% reduction in detrimental impacts on farm-level biodiversity via the use of circular techniques. Improving ocean health and water quality: a worldwide 80% decrease in plastics entering the ocean via reclamation, recycling, and other initiatives. Economic development and employment creation: a $4.5 trillion worldwide economic potential by 2030 created by fostering waste reduction innovation (Sharma et al., 2021).

The global demand for basic resources for items such as food, electronics, and clothing is rising quickly. A more environmentally friendly and competitive Europe is paved with the help of the European Union's new circular action plan. In March of 2020, the European Commission announced a new circular economy action plan (CEAP). It is one of the key pillars of the European Green Deal, Europe's new sustainable growth goal. The transformation of the EU to a circular economy would minimize reliance on natural resources and provide sustainable economic development and employment. It is also essential for achieving the EU's 2050 climate neutrality goal and halting biodiversity loss. The new action plan outlines efforts across the full product life cycle. It focuses on how goods are created, supports circular economy practices, supports sustainable consumption, and strives to reduce waste and keep as many resources as possible inside the EU economy (Eco-index, 2022).

It contains legislative and non-legislative actions aimed at areas where action at the EU level may provide a genuine added benefit. The efforts to be implemented under the revised action plan seek to (Giurco, 2020: 121)

- Implement sustainable goods the standard across the European Union
- Give buyers and the public more control
- Concentrate on industries with a strong potential for circularity, such as electronics, information and communications technology, batteries and vehicles, storage, plastic materials, textiles, infrastructure and constructions, food, clean water, and nutrients;
- Guarantee reduced waste
- Create circularity employment for individuals, regions, and urban areas
- Spearhead worldwide circular economy initiatives

Multi-criteria decision-making approaches are commonly employed in the assessment of circular economy and sustainable development objectives. In this research, the performance of 28 European Union member nations is evaluated through cluster analysis, and CRITIC-based MAUT and COPRAS methodologies, focusing on the circular economy. Considering the UN Sustainable Development Goals, this issue is particularly relevant to headings 9, 11, 12 and 13 in terms of content. In addition, the aim of this research is to draw attention to the topic of circular economy and hence these SDGs, as well as to contribute to the current literature on the subject. Furthermore, the research aims to compare the condition of the relevant nations to that of other countries in the study, as well as to inform academics and policymakers about the present circular economy performances of the relevant countries.

The rest of the research is organized as follows: The second part is a review of the literature on similar research. The methodologies utilized in the study are described in section 3. The findings are shown in section 4. Section 5 includes the discussion, while Section 6 presents the conclusion and recommendations.

2. LITERATURE REVIEW

The circular economy benefits the planet since it conserves and efficiently utilizes renewable materials. This is achieved by efficient use of resources and little waste production, particularly in industrial settings, and through minimal waste disposal at the end of the useful life of materials (Lieder and Rashid, 2016). In Figure 3, we see the most common topics covered in the literature and the top 10 nations for SDG12 and circular economy study.

When compared to the average annual growth rate of 3,5% for research on the other sustainable development goals, the yearly growth rate for research on SDG12 is 11.6%. The United States, the United Kingdom, India, and Italy all rank behind China as the countries where the most of these studies are conducted. China and Brazil have upper-middle income levels, while India has lower-middle income levels. Of the ten most productive nations, seven have high incomes (equal to over 37,400 publications). Not a single low-income nation is in the top 50 on this list. The top five nations where the largest percentage of research portfolios is devoted to SDG12 research are Malaysia, Ghana, Nigeria, Sri Lanka, and Latvia. International partnerships provide financing for 24 percent of SDG 12 research. The domain-weighted citation effect (FWCI), which measures academic influence, had a constant high of 1.36 on an annual average for SDG12 research across the time (RELX, 2022).

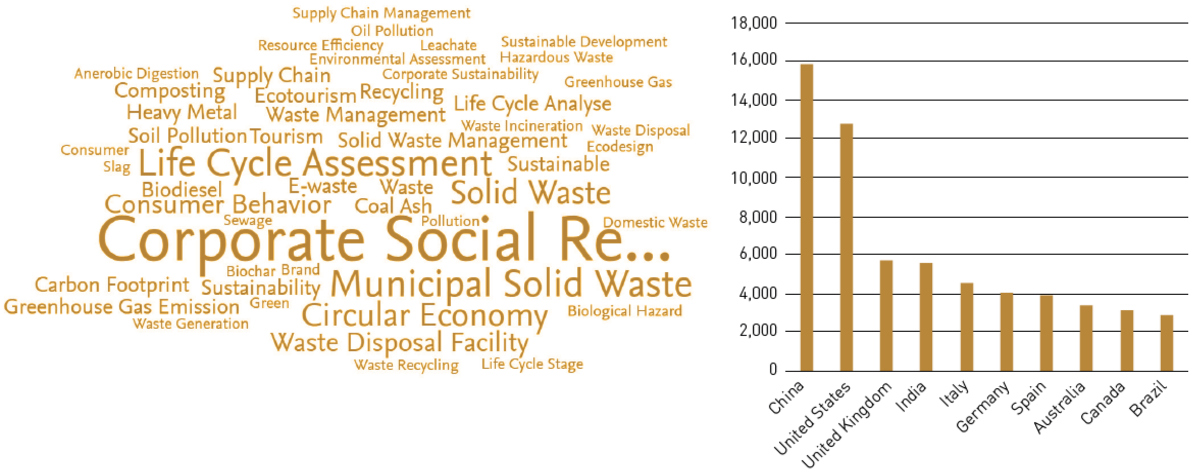

Figure 3. Statistics on the most-used keywords in articles on SDG12 and the circular economy, and the top 10 publishing countries (RELX, 2022)

A short literature overview of other research that have been discussed the circular economy and using comparable methods is shown below as follows:

The purpose of the study by Marino and Pariso (2020) was to evaluate the progress towards "Reduction, Reuse, Recycling" goals in the context of the circular economy by comparing the performance of the 28 EU Member States between 2006 and 2016. Growth Domestic Products in Purchasing Power Standards data were correlated with quantitative indicators in order to assess the efficacy of these measures.

Škrinjarić (2020) examined the performance of several European countries between 2010 and 2016 using the Grey Relational Analysis. There are clear indicators of regional disparities between European countries, as shown by the study. Countries in the European Union with the highest scores were Germany, the Netherlands, Denmark, France, and Italy, while the lowest scores were given to Romania, Greece, Cyprus, Slovakia, and Bulgaria. Increases in infrastructure, educational opportunities, and research and development (R&D) investment, as well as increases in GDP per cent, were all correlated with better economic success (research and development). Some of the lowest-ranked countries have inferior education PISA rankings, greater corruption indices, and lower government efficiency indices.

Smol (2021) gave a list of the performance indicators that were mentioned in the chosen CE national strategies. They pointed out that there is not one universal indicator that measures the level of CE transformation at the national level. This is because the issue is complicated and the key sectors and economic actors in each country are different.

The purpose of Lacko et al. (2021) study was to evaluate the effectiveness of the Visegrád Group in relation to the average efficiency of the 28 member states of European Union. Slack-based models in data envelopment analysis were used to assess the productivity of respondents. Additionally, the effect of certain indicators on overall circular efficiency was evaluated using truncated regression. This research demonstrates that the countries of the Visegrád Group are not in the forefront of recycling and circular economy adoption globally. This study demonstrated that greater GDP level does not always imply a higher degree of circular economy efficiency.

A thorough analysis and review of the circular economy concept as it applies to poor countries was presented by Ngan et al. (2019). In addition, a new model was suggested using Fuzzy Analytic Network Process (FANP) to measure the priority weights of the sustainability metrics in order to provide guidance for the key stakeholders throughout the various stages of the industry cycle as they make the shift toward a circular economy. According to the findings, better economic performance and widespread support are the primary motivators for stakeholders to support sustainable development.

The purpose of Mazur-Wierzbicka (2021)'s study was to compare the EU member states in terms of their level of circular economy implementation across multiple dimensions. The European Commission's suggested CE indicators were used as the foundation. In order to make comparisons, statistical approaches were used. The assessments led to the conclusion that the CE levels of the countries comprising the former EU are the highest of any in the EU.

Using an approach that relies on the Multidirectional Efficiency Analysis, Robaina et al. (2020) attempted to assess the efficiency of 26 European countries within the context of Circular Economy, for the timespan 2006-2016, taking into account the generation of waste, recovery, and recycling of plastic. Since most countries made similar use of the other inputs, an examination of inputs revealed that rising capital appears to be a primary driver towards efficiency. According to the results, the efficiency gap between nations does not lie in their ability to recycle more or produce less waste overall, but rather in their ability to grow their economies in a more circular fashion, which means increasing both their gross domestic product and their rate of recovery and recycling.

A Circular Economy Composite index was proposed by Garcia-Bernabeu et al. (2020) as a way to evaluate the performance of individual EU member states. They developed a composite index for the circular economy using TOPSIS (Technique for Ordering Preferences by Similarity to Ideal Solutions), a multi-criteria analysis technique. They used the approach to rank the EU Member States in terms of their Circular Economy performance in 2016. While the top countries were Germany, the UK, France, Italy, and the Netherlands, countries like Bulgaria, Romania, Greece, Malta, and Estonia were placed at the bottom of the list.

The goal of Ūsas et al. (2021) was to evaluate the state of the circular economy in each country in the EU. Together, these researchers created a quantitative framework that included tools like CRITIC-based TOPSIS, PROMETHEE II, and ELECTRE I. This study used the Eurostat statistics to collect the data needed to describe the growth of the circular economy on a national scale. It seemed like the most developed countries in terms of the circular economy were Germany, Sweden, and the Netherlands. According to the findings of analysis, Germany, the Netherlands, Denmark, France, and Italy scored the best, while Romania, Greece, Cyprus, Slovakia, and Bulgaria performed the worst.

Kaya et al. (2022) employed the cluster analysis and MCDM to assess the CE paradigm's impact on the societal development of EU member states. To classify the 27 EU members into clusters with comparable degrees of social effect from CE initiatives, a K-means cluster approach was performed. To achieve a fair balance between the two approaches, the weights of social indicators were calculated using the CRITIC and MEREC (Method based on the Removal Effects of Criteria) methodologies. Power averaging and the Heronian operator were employed along with the MARCOS (Measurement of Alternatives and Ranking according to Compromise Solution) technique to determine which nation performed best within each cluster. The top three nations were the Netherlands, Croatia, and Latvia.

3. METHODS and DATA

3.1. Dimensions and Indicators

The European Green Deal, developed by the European Commission, is at the forefront of global efforts to achieve SDG 12 and the circular economy. The Deal is more than just a new growth strategy in response to the threat of global warming and other environmental degradation; it is also a total transformation initiative. The issue of a circular economy is the primary focus on the list of priorities.

Data is gathered in 22 sub-indicators under three categories, including sustainable resource management (7), social behavior (6), and business operations (9) within the context of the European Union Environmental Consensus and Eco-Innovation Action Plan, with the purpose of assessing achievements in regard to this concept and comparing nations (Eco-index, 2022).

As a result, assessing the circular economy involves several factors and dimensions. The research aims to establish the weights of the indicators that use the CRITIC method to evaluate a variety of topics, including waste management, cyclical material use, recycling emphasis, and material efficiency. Additionally, all EU countries with data on relevant indicators will be evaluated using cluster analysis, a data mining technique, as well as MAUT and COPRAS methods, which are multi-criteria decision-making techniques.

When evaluating the performance of the circular economy, it is impossible to utilize a single statistic. However, there are currently a variety of indicators that may be used to track development in various sectors that contribute either directly or indirectly to the expansion of the Circular Economy. They may be classified as following (Eco-index, 2022):

Sustainable Resource Management: By reducing resource needs, boosting resource security, and reducing environmental pressures at home and abroad, the progress of EU Member States toward circularity is measured by this collection of indicators.

Societal Behaviour: These metrics represent the degree to which the general public is informed, interested, and active in the circular economy. The success of a transition to a circular economy relies heavily on citizen participation, behavioral shifts, and new social norms. What this means is that people are engaging in novel patterns of consumption (e.g., sharing, product-service systems, being willing to pay more for durability), re-use (demanding altered perspectives on rebuild and refurbishment), and disposal (trying to separate disposal streams and helping to bring "disposal" to remanufacturing/recycling/sorting regions).

Business Operations: This collection of metrics represents eco-innovation efforts aimed at modifying and adjusting business models to adhere to the tenets of a circular economy. Businesses are the driving force behind the move to a circular economy. They encourage circularity at all stages of the material life cycle, starting with the selection of raw materials (quality, environmental and health standards). Increased longevity and the capacity to reuse, remanufacture, and recycle products are essential to keeping resources in circulation for longer, and this process begins in the design phase. Remanufacturing and recycling are essential corporate processes for expanding the circular economy.

Table 1 presents the indicators and their dimensions (Eco-index, 2022).

Table 1. Dimensions, codes and indicators used in the analysis

Dimensions	*Codes*	*Indicators*
Sustainable Resource Management	C1	Material footprint: Domestic material consumption, tonnes per capita
	C2	Number of enterprises involved in the repair of computers and personal and household goods
	C3	Number of extended producer responsibility (EPR) schemes per member state
	C4	Municipal solid waste recycling rate (% of MSW recycled)
	C5	Recycling of packaging waste (in tonnes)
	C6	Recycling of bio-waste (in kg per capita)
	C7	Recycling of construction and demolition waste (%)
Societal Behaviours	C8	Purchasing refurbished products with a guarantee.
	C9	Leased or rented a product instead of buying it (e.g. a washing machine, furniture)
	C10	Used sharing schemes. These can be organized, like car or bike sharing schemes, or informal, like neighbours sharing lawn mowers.
	C11	Coverage of the circular economy topic in electronic mass media in 2016, number of published articles
	C12	Number of enterprises in repair of computers and personal and household goods across European countries
	C13	Number of enterprises in repair of computers and personal and household goods across European countries, Employment
Business Operations	C14	Lack of human resources
	C15	Lack of expertise to implement these activities
	C16	Complex administrative or legal procedures
	C17	Cost of meeting regulations or standards
	C18	Difficulties in accessing finance
	C19	Standard bank loan
	C20	It was self-financed
	C21	Availability of information that can help to access finance for circular economy related activities, as reported by SMEs
	C22	Number of eco labelled products and services

3.2. Methods

3.2.1. CRITIC (CRiteria Importance Through Inter- criteria Correlation) Method

The CRITIC technique is a weighing techniques used to estimate the objective weights of the criteria proposed by Diakoulaki et al. (1995). In this technique, the standard deviation of the criterion and the correlation between the criteria are taken into account while weighing them. This method's application approach consists of five phases, as indicated below (Diakoulaki et al., 1995).

Step 1: The performance of alternatives made up of various criteria and possibilities is displayed in the X matrix that is constructed. In Equation 1, a sample matrix X is displayed.

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}; i = 1, \dots \dots m \ ve \ j = 1, \dots n \quad (1)$$

Step 2: Depending on whether it is cost- or benefit-focused, the decision matrix is normalized. The decision matrix is normalized according to benefits using Equation 2. The matrix is normalized according to costs using Equation 3.

$$r_{ij} = \frac{X_{ij} - min\,X_{ij}}{maxX_{ij} - min\,X_{ij}} \quad (2)$$

$$r_{ij} = \frac{maxX_{ij} - X_{ij}}{maxX_{ij} - min\,X_{ij}} \quad (3)$$

Step 3: At this stage, the correlation coefficients are calculated employing Equation 4 using the data gathered from the previous step.

$$p_{jk} = \frac{\sum_{i=1}^{m}(r_{ij} - r_j) * (r_{ik} - r_k)}{\sqrt{\sum_{i=1}^{m}(x_{ij} - \overline{x}_j)^2 * \sum_{i=1}^{m}(x_{ik} - \overline{x}_k)^2}}; j, k = 1, \ldots, n \quad (4)$$

Step 4: The correlation coefficients are subtracted from one to get $1 - p_{jk}$ values. The value C_j is obtained by multiplying the cumulative sum of this acquired value by the standard deviation values σ_j. To calculate C_j, use Equation 5, and to calculate σ_j, use Equation 6.

$$c_j = \sigma_j \sum_{k=1}^{n}\left(1 - p_{jk}\right); \quad j = 1, \ldots, n \quad (5)$$

$$\sigma_j = \sqrt{\frac{1}{n-1}\sum_{j=1}^{n}(x_{ij} - \overline{x}_j)^2}; \; i = 1, \ldots, m \quad (6)$$

Step 5: The W_j values, for which the weights of the criteria are established, are obtained by dividing the derived C_j values by the total C_j values. Equation 7 is used to determine the w_j values.

$$w_j = \frac{c_j}{\sum_{i=1}^{n} c_j}; \; j = 1, \ldots, n \quad (7)$$

3.2.2. MAUT (Multi-attribute Utility Theory) Method

One of the MCDM techniques that enables the qualitative and quantitative criteria to be assessed jointly and identify the optimal option in terms of criteria is the Multi-Attributed Utility Theory (MAUT) approach (Fishburn and Keeney, 1974; Løken, 2007). According to Løken (2007), there are two stages to the method. The first stage involves normalizing the components of the decision matrix.

Step 1. The values of each criterion are first transformed during the normalization procedure so that the best value is one (1) and the worst value is zero (0). As a result, every number needs to fall between 0 and 1. Equation 8 is used to do this transition (Konuşkan et al., 2014):

$$\boldsymbol{u_i(x_i)} = \frac{\mathrm{x} - x_i}{\mathrm{x}_i^{+} - x_i^{-}} \quad (8)$$

where $\mathbf{x}_i^{+}$ is the highest value pertaining to the pertinent criteria, $\boldsymbol{x_i^{-}}$ is the pertinent criterion's lowest value and x is the cell's current value at the time of computation.

Step 2. Following the normalization procedure, each alternative's utility values are determined in the second phase. Equation 9 was used to calculate these benefit values, along with definitions of the variables utilized (Konuşkan et al., 2014):

$$\boldsymbol{U(x) = \sum_{1}^{m} u_i\,(x_i) * w_i} \quad (9)$$

where $\boldsymbol{U(x)}$ is the corresponding alternative's benefit value, $u_i(x_i)$ is the alternative's utility value according to the pertinent criteria and $\boldsymbol{w_i}$ is the corresponding criterion's weight value.

3.2.3. COPRAS (Complex Proportional Assessment) method

In the MCDM approach of COPRAS (Complex Proportional Assessment), the options are evaluated and ranked. Here are a few of the phases in the assessment of the method (Chatterjee et al., 2011; Das et al., 2012; Kaklauskas et al., 2010):

In the COPRAS technique, A_i is i[th] alternative $i = 1, 2, \ldots., m$; C_j is j[th] criterion $j = 1, 2, \ldots., n$; w_j is significance weight of the j[th] criterion $j = 1, 2, \ldots, n$; x_{ij} is j[th] level of evaluation criterion $j = 1,2, \ldots, n$.

Step 1. The x_{ij} values are used to create a decision matrix (Equation 10).

$$D = \begin{matrix} A_1 \\ A_2 \\ A_3 \\ . \\ A_m \end{matrix} \begin{bmatrix} x_{11} & x_{12} & x_{13} & . & x_{1n} \\ x_{21} & x_{22} & x_{23} & . & x_{2n} \\ x_{31} & x_{32} & x_{33} & . & x_{3n} \\ . & . & . & . & . \\ x_{m1} & x_{m2} & x_{m3} & . & x_{mn} \end{bmatrix} \quad (10)$$

Step 2. By dividing each value in the decision matrix by the sum of the corresponding column, each value is normalized (Equation 11).

$$X_{ij}^{*} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}, \forall_j = 1, 2, \dots, n \quad (11)$$

Step 3. The weight value ($\boldsymbol{w_j}$) of each evaluation metric is multiplied by the normalized decision matrix elements to create the dij components of the weighted normalized decision matrix D' (Equation 12).

$$D' = d_{ij} = x_{ij}^{*} \times w_j \quad (12)$$

Step 4. The computation of the weighted normalized decision matrix values for the benefit and cost criterion is done. S_i represents the complete value of the cost criteria, whereas S_{i+} represents the sum of the values in the i weighted normalized decision matrix for the benefit criteria. These values (Equation 12) can be computed using the formulas shown in equations Equation 13 and Equation 14.

$$S_{i+} = \sum_{j=1}^{k} d_{ij}, j = 1, 2, \dots, k \quad (13)$$

$$S_{i-} = \sum_{j=k+1}^{n} d_{ij}, j = k+1, k+2, \dots, n \quad (14)$$

Step 5. In this step, the relative significance value (Q_i) of each option is calculated (Equation 15).

$$Q_i = S_{i+} + \frac{\sum_{i=1}^{m} S_{i-}}{S_{i-} \times \sum_{i=1}^{m} \frac{1}{S_{i-}}} \quad (15)$$

Step 6. The highest priority is determined by a ranking system (Equation 16).

$$Q_{max} = max\{Q_i\}, \forall_i = 1, 2, \dots, n \quad (16)$$

Step 7. For every option, the performance index (P_i) scores are determined.

$$P_i = \frac{Q_i}{Q_{max}} \times \%100 \quad (17)$$

Performance index (P_i) of 100 is considered the greatest choice based on several assessment factors. The COPRAS assessment list is created by descendingly rating the performance index score of each option.

3.2.4. K-means Clustering Algorithm

A clustering method based on K-means has been published by MacQueen (1967), which seeks to define the cluster centers, $(c_1, \dots, c_k)$, in order to minimize the squared distances (Distortion, D) of each input point (x_i) to its nearest cluster centre (c_k), where d is a distance function. Euclidean distance is usually used as the d in most cases. Listed below are the steps involved (Azadnia et al., 2011):

(1) Identify the K center locations $(c_1, \dots, c_k)$.

(2) Distribute x_i to the cluster center c_k that is the closest.

(3) It is adjusted such that all cluster centers are based on an average of all x_i's closest to it.

(4) Do the following calculation $D = \sum_{i=1}^{n} [\min_{k=(1 \dots k)} d(x_i, c_i)]^2$

(5) If D's quantity converges, $(c_1, \dots, c_k)$ is returned; else, go to Step 2.

4. RESULTS

The decision matrix consisting of raw data used in the CRITIC, MAUT and COPRAS methods is presented in Table 2. The CRITIC method is an objective approach in which indicator weights are determined using raw data without subjective evaluations. The data used are 2021 data from the European Commission Environment Eco-innovation Action Plan database. In the first part of this section, calculation steps are given to show the stages of the CRITIC method.

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Table 2. CRITIC method decision matrix consisting raw data of indicators

	MIN	*MAX*	*MAX*	*MAX*	*MAX*	*MAX*	*MAX*	*MAX*	*MAX*	*MAX*	*MAX*
Countries	*C1*	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*
Austria	21,9	1.412	14	58	903.702	187	90	34	25	28	733
Belgium	12,9	3.236	11	55	1.491.974	82	97	35	37	36	1.570
Bulgaria	21,4	3.425	9	31	297.212	7	24	27	11	18	271
Croatia	9,7	1.375	5	25	140.538	12	78	16	9	3	414
Cyprus	13,7	456	3	16	51173	30	64	24	13	24	118
Czechia	15,7	7.976	4	34	880.893	26	92	35	26	23	275
Denmark	19,8	1.488	7	50	694.661	143	97	23	19	25	965
Estonia	27,0	424	8	28	123.682	15	95	26	31	23	37
EU-28	13,2	198.126	346	47	59.642.550	83	90	35	21	27	
Finland	30,5	1.457	16	42	484.505	72	74	33	25	59	2.611
France	11,3	33.686	20	45	8.803.425	100	73	35	25	35	6.639
Germany	16,1	13.689	13	67	13.085.174	110	93	48	3	31	8.235
Greece	12,7	6.507	8	20	539.900	21	97	25	14	3	1.060
Hungary	12,3	7.015	9	38	626.821	32	99	36	19	23	86
Ireland	20,7	1.635	5	38	681.164	40	100	33	25	25	231
Italy	6,9	25.108	40	50	8.829.486	105	98	22	14	19	6.282
Latvia	22,1	1.115	10	25	139.266	25	97	31	23	39	55
Lithuania	15,0	2.529	4	53	223.323	131	99	33	32	45	141
Luxembourg	21,9	114	4	49	92.417	136	98	29	27	34	270
Malta	13,4	357	2	10	24476	0	100	12	7	15	35
Netherlands	11,1	10.023	14	56	2.452.000	147	100	35	26	29	4.975
Poland	16,9	19.748	12	34	3.316.229	27	84	37	14	22	536
Portugal	15,8	4.841	12	29	945.236	85	93	29	15	3	368
Romania	23,3	3.964	9	11	850.620	9	74	25	9	13	458
Slovakia	12,7	3.196	16	36	339.904	39	51	29	27	27	87
Slovenia	13,3	1.220	9	59	164.069	79	98	29	2	26	379
Spain	8,3	28.657	13	35	5.162.577	84	75	37	19	32	8.765
Sweden	22,5	4.128	11	46	942.950	69	90	23	27	26	1.339
UK	8,8	9.345	58	44	7.356.629	78	98	45	23	22	4.324
Max	30,5	198.126,0	346,0	67,2	59.642.550,0	187,0	100,0	48,0	37,0	59,0	8.765
Min	6,9	114,0	2,0	10,0	24.476,0	0,0	24,0	12,0	2,0	3,0	35,0

	MIN	*MAX*	*MAX*	*MAX*	*MAX*	*MAX*	*MAX*	*MAX*	*MAX*	*MAX*	*MAX*
Countries	*C12*	*C13*	*C14*	*C15*	*C16*	*C17*	*C18*	*C19*	*C20*	*C21*	*C22*
Austria	1.437	2.743	13	16	22	28	16	16	7	16	494
Belgium	3.015	1.814	24	24	38	39	15	23	65	12	2.065
Bulgaria	3.516	2.817	3	18	35	22	35	18	65	5	100
Croatia	1.575	3.150	14	15	3	15	2	5	67	8	100
Cyprus	388	182	12	17	28	15	25	2	79	3	100
Czechia	7.856	8.851	28	21	46	35	24	7	81	9	128
Denmark	1.544	3.426	8	8	14	13	8	5	78	7	1.929
Estonia	417	953	17	13	13	14	19	6	82	6	781
EU-28	209.739	229.749,0	21	22	34	32	27	13	7	7	70.692
Finland	1.672	2.631	16	26	33	32	13	5	84	7	618
France	53.918	38.832	36	35	59	53	37	14	68	5	7.226
Germany	12.026	28.859	16	13	21	21	14	1	6	11	6.053
Greece	6.923	3.030	13	19	36	18	45	7	74	8	3.523
Hungary	5.888	6.339	32	21	43	29	38	9	75	15	100
Ireland	1.538	1.574	21	25	22	31	27	13	71	6	100
Italy	25.018	15.908	14	15	38	3	33	19	64	4	5.751
Latvia	1.106	1.803	31	36	32	37	3	5	77	8	100
Lithuania	2.657	1.549	23	17	24	16	26	1	74	11	458
Luxembourg	118	209	15	19	23	27	14	1	67	16	100
Malta	258	65	24	2	2	17	1	9	65	27	100
Netherlands	9.269	4.855	19	21	21	36	2	6	78	9	1.469
Poland	20.697	12.229	27	35	5	45	41	12	72	8	2.727
Portugal	4.840	4.389	17	17	27	22	24	12	78	7	3.023
Romania	3.562	9.570	39	38	32	33	31	11	72	9	100
Slovakia	2.892	1.023	21	18	45	31	33	7	71	6	100
Slovenia	1.127	734	15	18	36	21	25	11	69	11	100
Spain	24.583	28.472	18	3	31	31	3	18	65	4	27.018
Sweden	4.423	4.348	2	18	2	21	19	6	78	4	4.597
UK	7.476	39.394	17	17	12	22	14	6	76	1	2.362
Max	209.739,0	229.749,0	39,0	38,0	59,0	53,0	45,0	23,0	84,0	27,0	70.692,0
Min	1.437	2.743	13	16	22	28	16	16	7	16	494

After the cost (min) indicators in the decision matrix are converted to benefit (max) indicators with $1/x$ conversion, $X' = (X - X_{min})/(X_{max} - X_{min})$ normalization process is applied to all indicators in the new decision matrix so that the analysis is not affected by extreme values and it is possible to evaluate indicators with different units together. The indicator values were converted to be in the 0-1 value range. The resulting normalized decision matrix is shown in Table 3.

Table 3. CRITIC method normalized decision matrix

Countries	*C1*	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*
Austria	0.368	0.007	0.035	0.834	0.015	1.000	0.868	0.611	0.657	0.446	0.080
Belgium	0.747	0.016	0.026	0.779	0.025	0.439	0.961	0.639	1.000	0.589	0.176
Bulgaria	0.388	0.017	0.020	0.376	0.005	0.037	0.000	0.417	0.257	0.268	0.027
Croatia	0.882	0.006	0.009	0.267	0.002	0.064	0.711	0.111	0.200	0.000	0.043
Cyprus	0.713	0.002	0.003	0.109	0.000	0.160	0.526	0.333	0.314	0.375	0.010
Czech Republic	0.629	0.040	0.006	0.429	0.014	0.139	0.895	0.639	0.686	0.357	0.027
Denmark	0.455	0.007	0.015	0.698	0.011	0.765	0.961	0.306	0.486	0.393	0.107
Estonia	0.149	0.002	0.017	0.314	0.002	0.080	0.934	0.389	0.829	0.357	0.000
EU-28	0.735	1.000	1.000	0.646	1.000	0.444	0.868	0.639	0.543	0.429	-0.004
Finland	0.000	0.007	0.041	0.565	0.008	0.385	0.658	0.583	0.657	1.000	0.295
France	0.817	0.170	0.052	0.612	0.147	0.535	0.645	0.639	0.657	0.571	0.756
Germany	0.612	0.069	0.032	1.000	0.219	0.588	0.908	1.000	0.029	0.500	0.939
Greece	0.756	0.032	0.017	0.176	0.009	0.112	0.961	0.361	0.343	0.000	0.117
Hungary	0.774	0.035	0.020	0.482	0.010	0.171	0.987	0.667	0.486	0.357	0.006
Ireland	0.418	0.008	0.009	0.484	0.011	0.214	1.000	0.583	0.657	0.393	0.022
Italy	1.000	0.126	0.110	0.698	0.148	0.561	0.974	0.278	0.343	0.286	0.716
Latvia	0.359	0.005	0.023	0.268	0.002	0.134	0.961	0.528	0.600	0.643	0.002
Lithuania	0.660	0.012	0.006	0.745	0.003	0.701	0.987	0.583	0.857	0.750	0.012
Luxembourg	0.366	0.000	0.006	0.682	0.001	0.727	0.974	0.472	0.714	0.554	0.027
Malta	0.727	0.001	0.000	0.000	0.000	0.000	1.000	0.000	0.143	0.214	0.000
Netherlands	0.826	0.050	0.035	0.804	0.041	0.786	1.000	0.639	0.686	0.464	0.566
Poland	0.577	0.099	0.029	0.414	0.055	0.144	0.789	0.694	0.343	0.339	0.057
Portugal	0.626	0.024	0.029	0.336	0.015	0.455	0.908	0.472	0.371	0.000	0.038
Romania	0.305	0.019	0.020	0.019	0.014	0.048	0.658	0.361	0.200	0.179	0.048
Slovakia	0.758	0.016	0.041	0.459	0.005	0.209	0.355	0.472	0.714	0.429	0.006
Slovenia	0.732	0.006	0.020	0.855	0.002	0.422	0.974	0.472	0.000	0.411	0.039
Spain	0.942	0.144	0.032	0.437	0.086	0.449	0.671	0.694	0.486	0.518	1.000
Sweden	0.338	0.020	0.026	0.628	0.015	0.369	0.868	0.306	0.714	0.411	0.149
United Kingdom	0.919	0.047	0.163	0.596	0.123	0.417	0.974	0.917	0.600	0.339	0.491
Countries	*C12*	*C13*	*C14*	*C15*	*C16*	*C17*	*C18*	*C19*	*C20*	*C21*	*C22*
Austria	0.006	0.012	0.703	0.611	0.649	0.500	0.659	0.318	0.013	0.577	0.006
Belgium	0.014	0.008	0.405	0.389	0.368	0.280	0.682	0.000	0.756	0.423	0.028
Bulgaria	0.016	0.012	0.973	0.556	0.421	0.620	0.227	0.227	0.756	0.154	0.000
Croatia	0.007	0.013	0.676	0.639	0.982	0.760	0.977	0.818	0.782	0.269	0.000
Cyprus	0.001	0.001	0.730	0.583	0.544	0.760	0.455	0.955	0.936	0.077	0.000
Czech Republic	0.037	0.038	0.297	0.472	0.228	0.360	0.477	0.727	0.962	0.308	0.000
Denmark	0.007	0.015	0.838	0.833	0.789	0.800	0.841	0.818	0.923	0.231	0.026
Estonia	0.001	0.004	0.595	0.694	0.807	0.780	0.591	0.773	0.974	0.192	0.010
EU-28	1.000	1.000	0.486	0.444	0.439	0.420	0.409	0.455	0.013	0.231	1.000
Finland	0.007	0.011	0.622	0.333	0.456	0.420	0.727	0.818	1.000	0.231	0.007
France	0.257	0.169	0.081	0.083	0.000	0.000	0.182	0.409	0.795	0.154	0.101
Germany	0.057	0.125	0.622	0.694	0.667	0.640	0.705	1.000	0.000	0.385	0.084
Greece	0.032	0.013	0.703	0.528	0.404	0.700	0.000	0.727	0.872	0.269	0.048
Hungary	0.028	0.027	0.189	0.472	0.281	0.480	0.159	0.636	0.885	0.538	0.000
Ireland	0.007	0.007	0.486	0.361	0.649	0.440	0.409	0.455	0.833	0.192	0.000
Italy	0.119	0.069	0.676	0.639	0.368	1.000	0.273	0.182	0.744	0.115	0.080
Latvia	0.005	0.008	0.216	0.056	0.474	0.320	0.955	0.818	0.910	0.269	0.000
Lithuania	0.012	0.006	0.432	0.583	0.614	0.740	0.432	1.000	0.872	0.385	0.005
Luxembourg	0.000	0.001	0.649	0.528	0.632	0.520	0.705	1.000	0.782	0.577	0.000
Malta	0.001	0.000	0.405	1.000	1.000	0.720	1.000	0.636	0.756	1.000	0.000
Netherlands	0.044	0.021	0.541	0.472	0.667	0.340	0.977	0.773	0.923	0.308	0.019
Poland	0.098	0.053	0.324	0.083	0.947	0.160	0.091	0.500	0.846	0.269	0.037
Portugal	0.023	0.019	0.595	0.583	0.561	0.620	0.477	0.500	0.923	0.231	0.041
Romania	0.016	0.041	0.000	0.000	0.474	0.400	0.318	0.545	0.846	0.308	0.000
Slovakia	0.013	0.004	0.486	0.556	0.246	0.440	0.273	0.727	0.833	0.192	0.000
Slovenia	0.005	0.003	0.649	0.556	0.404	0.640	0.455	0.545	0.808	0.385	0.000
Spain	0.117	0.124	0.568	0.972	0.491	0.440	0.955	0.227	0.756	0.115	0.381
Sweden	0.021	0.019	1.000	0.556	1.000	0.640	0.591	0.773	0.923	0.115	0.064
United Kingdom	0.035	0.171	0.595	0.583	0.825	0.620	0.705	0.773	0.897	0.000	0.032

After this stage, correlation coefficients are calculated by using the normalized decision matrix data. The correlation coefficient findings of circular economy indicators are presented in Table 4.

Table 4. CRITIC method correlation coefficient results

	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*
C1	0.219	1	0.973	0.146	0.981	0.098	0.018	0.199	0.013	0.038	0.0661
C2	0.161	0.973	1	0.151	0.972	0.097	0.046	0.18	0.042	0.031	-0.036
C3	0.09	0.146	0.151	1	0.226	0.805	0.286	0.557	0.261	0.495	0.4023
C4	0.216	0.981	0.972	0.226	1	0.146	0.057	0.268	-0.03	0.053	0.133
C5	0.069	0.098	0.097	0.805	0.146	1	0.333	0.357	0.299	0.407	0.3848
C6	0.115	0.018	0.046	0.286	0.057	0.333	1	0.112	0.168	0.029	0.0259
C7	0.084	0.199	0.18	0.557	0.268	0.357	0.112	1	0.246	0.442	0.4497
C8	-0.21	0.013	0.042	0.261	-0.03	0.299	0.168	0.246	1	0.516	-0.094
C9	-0.33	0.038	0.031	0.495	0.053	0.407	0.029	0.442	0.516	1	0.2197
C10	0.399	0.066	-0.036	0.402	0.133	0.385	0.026	0.45	-0.094	0.22	1
C11	0.217	0.996	0.961	0.147	0.974	0.103	0.004	0.193	0.026	0.049	0.073
C12	0.208	0.986	0.98	0.161	0.989	0.103	0.03	0.262	0.003	0.043	0.0855
C13	-0.11	-0.103	-0.032	0.237	-0.064	0.229	-0.174	-0.243	-0.107	-0.125	0.008
C14	0.273	-0.078	-0.059	0.088	-0.045	0.182	0.097	-0.255	-0.165	-0.197	0.1686
C15	-0.19	-0.173	-0.107	-0.103	-0.132	-0.021	0.267	-0.273	-0.146	-0.227	-0.159
C16	0.073	-0.181	-0.092	-0.07	-0.121	0.002	0.125	-0.496	-0.327	-0.359	-0.097
C17	-0.06	-0.142	-0.097	0.104	-0.097	0.247	0.265	-0.092	0.079	0.228	0.1871
C18	-0.23	-0.217	-0.159	-0.061	-0.158	-0.003	0.188	-0.032	-0.026	0.134	-0.178
C19	-0.08	-0.542	-0.531	-0.43	-0.625	-0.39	-0.032	-0.33	0.199	-0.041	-0.216
C20	-0.06	-0.137	-0.138	-0.026	-0.134	0.061	0.348	-0.222	-0.135	-0.002	-0.281
C21	0.227	0.963	0.924	0.132	0.938	0.12	0.008	0.202	0.013	0.056	0.1554
C22	0.219	1	0.973	0.146	0.981	0.098	0.018	0.199	0.013	0.038	0.0661

	C12	*C13*	*C14*	*C15*	*C16*	*C17*	*C18*	*C19*	*C20*	*C21*	*C22*
C1	0.217	0.208	-0.112	0.273	-0.185	0.073	-0.061	-0.231	-0.078	-0.064	0.227
C2	0.996	0.986	-0.103	-0.078	-0.173	-0.181	-0.142	-0.217	-0.542	-0.137	0.963
C3	0.961	0.98	-0.032	-0.059	-0.107	-0.092	-0.097	-0.159	-0.531	-0.138	0.924
C4	0.147	0.161	0.237	0.088	-0.103	-0.07	0.104	-0.061	-0.43	-0.026	0.132
C5	0.974	0.989	-0.064	-0.045	-0.132	-0.121	-0.097	-0.158	-0.625	-0.134	0.938
C6	0.103	0.103	0.229	0.182	-0.021	0.002	0.247	-0.003	-0.39	0.061	0.12
C7	0.004	0.03	-0.174	0.097	0.267	0.125	0.265	0.188	-0.032	0.348	0.008
C8	0.193	0.262	-0.243	-0.255	-0.273	-0.496	-0.092	-0.032	-0.33	-0.222	0.202
C9	0.026	0.003	-0.107	-0.165	-0.146	-0.327	0.079	-0.026	0.199	-0.135	0.013
C10	0.049	0.043	-0.125	-0.197	-0.227	-0.359	0.228	0.134	-0.041	-0.002	0.056
C11	0.073	0.085	0.008	0.169	-0.159	-0.097	0.187	-0.178	-0.216	-0.281	0.155
C12	1	0.981	-0.132	-0.118	-0.207	-0.22	-0.168	-0.222	-0.53	-0.141	0.948
C13	0.981	1	-0.099	-0.066	-0.138	-0.169	-0.097	-0.159	-0.566	-0.154	0.951
C14	-0.13	-0.099	1	0.588	0.397	0.626	0.173	0.091	-0.086	-0.234	-0.02
C15	-0.12	-0.066	0.588	1	0.352	0.682	0.412	0.077	-0.139	0.21	0.068
C16	-0.21	-0.138	0.397	0.352	1	0.386	0.48	0.329	9E-05	0.171	-0.128
C17	-0.22	-0.169	0.626	0.682	0.386	1	0.124	0.253	0.026	-0.003	-0.135
C18	-0.17	-0.097	0.173	0.412	0.48	0.124	1	0.232	-0.043	0.24	-0.022
C19	-0.22	-0.159	0.091	0.077	0.329	0.253	0.232	1	0.19	0.058	-0.242
C20	-0.53	-0.566	-0.086	-0.139	9E-05	0.026	-0.043	0.19	1	-0.246	-0.536
C21	-0.14	-0.154	-0.234	0.21	0.171	-0.003	0.24	0.058	-0.246	1	-0.163
C22	0.948	0.951	-0.02	0.068	-0.128	-0.135	-0.022	-0.242	-0.536	-0.163	1

After the correlation coefficients are calculated, they are subtracted from 1 and $1 - P_{jk}$ values are obtained. The cumulative sums of this obtained value are multiplied by the standard deviation values σ_j to obtain the C_j value. The obtained P_{jk}, σ_j and C_j results are presented in Table 5.

Table 5. $1 - P_{jk}$, σ_j **and** C_j **Values**

	C1	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*
C1	0	0.781	0.839	0.91	0.784	0.931	0.885	0.916	1.209	1.329	0.601
C2	0.781	0	0.027	0.854	0.019	0.902	0.982	0.801	0.987	0.962	0.933
C3	0.839	0.027	0	0.849	0.028	0.903	0.954	0.82	0.958	0.969	1.036
C4	0.91	0.854	0.849	0	0.774	0.195	0.714	0.443	0.739	0.505	0.597
C5	0.784	0.019	0.028	0.774	0	0.854	0.943	0.732	1.03	0.947	0.867
C6	0.931	0.902	0.903	0.195	0.854	0	0.667	0.643	0.701	0.593	0.615
C7	0.885	0.982	0.954	0.714	0.943	0.667	0	0.888	0.832	0.971	0.974
C8	0.916	0.801	0.82	0.443	0.732	0.643	0.888	0	0.754	0.558	0.550
C9	1.209	0.987	0.958	0.739	1.03	0.701	0.832	0.754	0	0.484	1.094
C10	1.329	0.962	0.969	0.505	0.947	0.593	0.971	0.558	0.484	0	0.780
C11	0.601	0.934	1.036	0.598	0.867	0.615	0.974	0.55	1.094	0.78	0
C12	0.783	0.004	0.039	0.853	0.026	0.897	0.996	0.807	0.974	0.951	0.927
C13	0.792	0.014	0.02	0.839	0.011	0.897	0.97	0.738	0.997	0.957	0.914
C14	1.112	1.103	1.032	0.763	1.064	0.771	1.174	1.243	1.107	1.125	0.992
C15	0.727	1.078	1.059	0.912	1.045	0.818	0.903	1.255	1.165	1.197	0.831
C16	1.185	1.173	1.107	1.103	1.132	1.021	0.733	1.273	1.146	1.227	1.158
C17	0.927	1.181	1.092	1.07	1.121	0.998	0.875	1.496	1.327	1.359	1.097
C18	1.061	1.142	1.097	0.896	1.097	0.753	0.735	1.092	0.921	0.772	0.813
C19	1.231	1.217	1.159	1.061	1.158	1.003	0.812	1.032	1.026	0.866	1.178
C20	1.078	1.542	1.531	1.43	1.625	1.39	1.032	1.33	0.801	1.041	1.216
C21	1.064	1.137	1.138	1.026	1.134	0.939	0.652	1.222	1.135	1.002	1.281
C22	0.773	0.037	0.076	0.868	0.062	0.88	0.992	0.798	0.987	0.944	0.8446

	C12	*C13*	*C14*	*C15*	*C16*	*C17*	*C18*	*C19*	*C20*	*C21*	*C22*
C1	0.783	0.792	1.112	0.727	1.185	0.927	1.061	1.231	1.078	1.064	0.773
C2	0.004	0.014	1.103	1.078	1.173	1.181	1.142	1.217	1.542	1.137	0.037
C3	0.039	0.02	1.032	1.059	1.107	1.092	1.097	1.159	1.531	1.138	0.076
C4	0.853	0.839	0.763	0.912	1.103	1.07	0.896	1.061	1.43	1.026	0.868
C5	0.026	0.011	1.064	1.045	1.132	1.121	1.097	1.158	1.625	1.134	0.062
C6	0.897	0.897	0.771	0.818	1.021	0.998	0.753	1.003	1.39	0.939	0.88
C7	0.996	0.97	1.174	0.903	0.733	0.875	0.735	0.812	1.032	0.652	0.992
C8	0.807	0.738	1.243	1.255	1.273	1.496	1.092	1.032	1.33	1.222	0.798
C9	0.974	0.997	1.107	1.165	1.146	1.327	0.921	1.026	0.801	1.135	0.987
C10	0.951	0.957	1.125	1.197	1.227	1.359	0.772	0.866	1.041	1.002	0.944
C11	0.927	0.915	0.992	0.831	1.159	1.097	0.813	1.178	1.216	1.281	0.845
C12	0	0.019	1.132	1.118	1.207	1.22	1.168	1.222	1.53	1.141	0.052
C13	0.019	0	1.099	1.066	1.138	1.169	1.097	1.159	1.566	1.154	0.049
C14	1.132	1.099	0	0.412	0.603	0.374	0.827	0.909	1.086	1.234	1.02
C15	1.118	1.066	0.412	0	0.648	0.318	0.588	0.923	1.139	0.79	0.932
C16	1.207	1.138	0.603	0.648	0	0.614	0.52	0.671	1	0.829	1.128
C17	1.22	1.169	0.374	0.318	0.614	0	0.876	0.747	0.974	1.003	1.135
C18	1.168	1.097	0.827	0.588	0.52	0.876	0	0.768	1.043	0.76	1.022
C19	1.222	1.159	0.909	0.923	0.671	0.747	0.768	0	0.81	0.942	1.242
C20	1.53	1.566	1.086	1.139	1	0.974	1.043	0.81	0	1.246	1.536
C21	1.141	1.154	1.234	0.79	0.829	1.003	0.76	0.942	1.246	0	1.163
C22	0.052	0.049	1.02	0.932	1.128	1.135	1.022	1.242	1.536	1.163	0

In the last step, the w_j values are obtained by dividing the C_j values by the total C_j values. The w_j values for the indicators that constitute the subject of the research are presented in Table 6.

Table 6. CRITIC Weight (w_j) Values of Indicators

Definitions	*Codes*	*Weights*
It was self-financed	C20	0.072503
Coverage of the circular economy topic in electronic mass media in 2016, number of articles published	C11	0.059900
Standard bank loan	C19	0.057043
Difficulties in accessing finance	C18	0.056018
Leased or rented a product instead of buying it (e.g. a washing machine, furniture)	C9	0.052565
Complex administrative or legal procedures	C16	0.052525
Material footprint: Domestic Material Consumption, tonnes per capita, 2016	C1	0.050434
Lack of human resources	C14	0.048651
Recycling of biowaste (in kg per capita), 2016- 2019	C6	0.047437
Lack of expertise to implement these activities	C15	0.046438
Cost of meeting regulations or standards	C17	0.046077
Municipal solid waste recycling rate (% of MSW recycled), 2019	C4	0.045620
Availability of information that can help to access finance for circular economy related activities, as reported by smes, 2016, Sufficient information is readily available	C21	0.044189
Recycling of construction and demolition waste (%), 2019	C7	0.043680
Used sharing schemes. These can be organised, like car or bike sharing schemes, or informal, like neighbours sharing lawn mowers.	C10	0.042613
Purchasing refurbished products with a guarantee.	C8	0.042275
Number of eco labelled products and services, March 2020	C22	0.032763
Number of enterprises in repair of computers and personal and household goods across european countries, 2007-2014, Enterprises	C12	0.032687
Number of enterprises involved in the repair of computers and personal and household goods, 2019	C2	0.031923
Number of enterprises in repair of computers and personal and household goods across european countries, 2007-2014, Employment	C13	0.031697
Recycling of packaging waste (in tonnes), 2018	C5	0.031595
Number of Extended Producer Responsibility (EPR) schemes per Member State, 2019 Extended Producer Responsibility	C3	0.031369

The normalized decision matrix used in MAUT and COPRAS analyzes is shown in Table 7.

Table 7. MAUT and COPRAS normalized decision matrix

Weights	0.050	0.032	0.031	0.046	0.032	0.047	0.044	0.042	0.053	0.043	0.060
Countries	*C1*	*C2*	*C3*	*C4*	*C5*	*C6*	*C7*	*C8*	*C9*	*C10*	*C11*
Austria	0.368	0.007	0.035	0.834	0.015	1.000	0.868	0.611	0.657	0.446	0.080
Belgium	0.747	0.016	0.026	0.779	0.025	0.439	0.961	0.639	1.000	0.589	0.176
Bulgaria	0.388	0.017	0.020	0.376	0.005	0.037	0.000	0.417	0.257	0.268	0.027
Croatia	0.882	0.006	0.009	0.267	0.002	0.064	0.711	0.111	0.200	0.000	0.043
Cyprus	0.713	0.002	0.003	0.109	0.000	0.160	0.526	0.333	0.314	0.375	0.010
Czech Republic	0.629	0.040	0.006	0.429	0.014	0.139	0.895	0.639	0.686	0.357	0.027
Denmark	0.455	0.007	0.015	0.698	0.011	0.765	0.961	0.306	0.486	0.393	0.107
Estonia	0.149	0.002	0.017	0.314	0.002	0.080	0.934	0.389	0.829	0.357	0.000
EU-28	0.735	1.000	1.000	0.646	1.000	0.444	0.868	0.639	0.543	0.429	0.004
Finland	0.000	0.007	0.041	0.565	0.008	0.385	0.658	0.583	0.657	1.000	0.295
France	0.817	0.170	0.052	0.612	0.147	0.535	0.645	0.639	0.657	0.571	0.756
Germany	0.612	0.069	0.032	1.000	0.219	0.588	0.908	1.000	0.029	0.500	0.939
Greece	0.756	0.032	0.017	0.176	0.009	0.112	0.961	0.361	0.343	0.000	0.117
Hungary	0.774	0.035	0.020	0.482	0.010	0.171	0.987	0.667	0.486	0.357	0.006
Ireland	0.418	0.008	0.009	0.484	0.011	0.214	1.000	0.583	0.657	0.393	0.022
Italy	1.000	0.126	0.110	0.698	0.148	0.561	0.974	0.278	0.343	0.286	0.716
Latvia	0.359	0.005	0.023	0.268	0.002	0.134	0.961	0.528	0.600	0.643	0.002
Lithuania	0.660	0.012	0.006	0.745	0.003	0.701	0.987	0.583	0.857	0.750	0.012
Luxembourg	0.366	0.000	0.006	0.682	0.001	0.727	0.974	0.472	0.714	0.554	0.027
Malta	0.727	0.001	0.000	0.000	0.000	0.000	1.000	0.000	0.143	0.214	0.000
Netherlands	0.826	0.050	0.035	0.804	0.041	0.786	1.000	0.639	0.686	0.464	0.566
Poland	0.577	0.099	0.029	0.414	0.055	0.144	0.789	0.694	0.343	0.339	0.057
Portugal	0.626	0.024	0.029	0.336	0.015	0.455	0.908	0.472	0.371	0.000	0.038
Romania	0.305	0.019	0.020	0.019	0.014	0.048	0.658	0.361	0.200	0.179	0.048
Slovakia	0.758	0.016	0.041	0.459	0.005	0.209	0.355	0.472	0.714	0.429	0.006
Slovenia	0.732	0.006	0.020	0.855	0.002	0.422	0.974	0.472	0.000	0.411	0.039
Spain	0.942	0.144	0.032	0.437	0.086	0.449	0.671	0.694	0.486	0.518	1.000
Sweden	0.338	0.020	0.026	0.628	0.015	0.369	0.868	0.306	0.714	0.411	0.149
United Kingdom	0.919	0.047	0.163	0.596	0.123	0.417	0.974	0.917	0.600	0.339	0.491
Weights	0.033	0.032	0.049	0.046	0.053	0.046	0.056	0.057	0.073	0.044	0.033
Countries	*C12*	*C13*	*C14*	*C15*	*C16*	*C17*	*C18*	*C19*	*C20*	*C21*	*C22*
Austria	0.006	0.012	0.703	0.611	0.649	0.500	0.659	0.318	0.013	0.577	0.006
Belgium	0.014	0.008	0.405	0.389	0.368	0.280	0.682	0.000	0.756	0.423	0.028
Bulgaria	0.016	0.012	0.973	0.556	0.421	0.620	0.227	0.227	0.756	0.154	0.000
Croatia	0.007	0.013	0.676	0.639	0.982	0.760	0.977	0.818	0.782	0.269	0.000
Cyprus	0.001	0.001	0.730	0.583	0.544	0.760	0.455	0.955	0.936	0.077	0.000
Czech Republic	0.037	0.038	0.297	0.472	0.228	0.360	0.477	0.727	0.962	0.308	0.000
Denmark	0.007	0.015	0.838	0.833	0.789	0.800	0.841	0.818	0.923	0.231	0.026
Estonia	0.001	0.004	0.595	0.694	0.807	0.780	0.591	0.773	0.974	0.192	0.010
EU-28	1.000	1.000	0.486	0.444	0.439	0.420	0.409	0.455	0.013	0.231	1.000
Finland	0.007	0.011	0.622	0.333	0.456	0.420	0.727	0.818	1.000	0.231	0.007
France	0.257	0.169	0.081	0.083	0.000	0.000	0.182	0.409	0.795	0.154	0.101
Germany	0.057	0.125	0.622	0.694	0.667	0.640	0.705	1.000	0.000	0.385	0.084
Greece	0.032	0.013	0.703	0.528	0.404	0.700	0.000	0.727	0.872	0.269	0.048
Hungary	0.028	0.027	0.189	0.472	0.281	0.480	0.159	0.636	0.885	0.538	0.000
Ireland	0.007	0.007	0.486	0.361	0.649	0.440	0.409	0.455	0.833	0.192	0.000
Italy	0.119	0.069	0.676	0.639	0.368	1.000	0.273	0.182	0.744	0.115	0.080
Latvia	0.005	0.008	0.216	0.056	0.474	0.320	0.955	0.818	0.910	0.269	0.000
Lithuania	0.012	0.006	0.432	0.583	0.614	0.740	0.432	1.000	0.872	0.385	0.005
Luxembourg	0.000	0.001	0.649	0.528	0.632	0.520	0.705	1.000	0.782	0.577	0.000
Malta	0.001	0.000	0.405	1.000	1.000	0.720	1.000	0.636	0.756	1.000	0.000
Netherlands	0.044	0.021	0.541	0.472	0.667	0.340	0.977	0.773	0.923	0.308	0.019
Poland	0.098	0.053	0.324	0.083	0.947	0.160	0.091	0.500	0.846	0.269	0.037
Portugal	0.023	0.019	0.595	0.583	0.561	0.620	0.477	0.500	0.923	0.231	0.041
Romania	0.016	0.041	0.000	0.000	0.474	0.400	0.318	0.545	0.846	0.308	0.000
Slovakia	0.013	0.004	0.486	0.556	0.246	0.440	0.273	0.727	0.833	0.192	0.000
Slovenia	0.005	0.003	0.649	0.556	0.404	0.640	0.455	0.545	0.808	0.385	0.000
Spain	0.117	0.124	0.568	0.972	0.491	0.440	0.955	0.227	0.756	0.115	0.381
Sweden	0.021	0.019	1.000	0.556	1.000	0.640	0.591	0.773	0.923	0.115	0.064
United Kingdom	0.035	0.171	0.595	0.583	0.825	0.620	0.705	0.773	0.897	0.000	0.032

The rankings obtained from the MAUT and COPRAS analysis are presented in Table 8.

Table 8. Rankings obtained from MAUT and COPRAS analysis

MAUT Method Ranking		*COPRAS Method Ranking*	
Countries	*Benefit Value (U_i)*	*Countries*	*Benefit Value (N_i)*
Netherlands	0.5610	Netherlands	100.00
United Kingdom	0.5447	United Kingdom	87.29
EU-28	0.5378	Spain	81.19
Spain	0.5287	EU-28	73.92
Denmark	0.5258	Germany	71.78
Germany	0.5246	France	70.21
France	0.5234	Italy	70.19
Luxembourg	0.5014	Denmark	58.08
Sweden	0.4890	Lithuania	56.98
Italy	0.4697	Sweden	55.49
Lithuania	0.4540	Luxembourg	54.71
Finland	0.4402	Finland	53.24
Estonia	0.4386	Austria	52.51
Belgium	0.4367	Belgium	51.70
Austria	0.4299	Malta	46.73
Malta	0.4289	Slovenia	45.08
Slovenia	0.4196	Estonia	44.91
Portugal	0.4012	Poland	44.69
Czech Republic	0.3977	Portugal	44.57
Cyprus	0.3963	Croatia	44.00
Latvia	0.3921	Czech Republic	43.74
Croatia	0.3884	Hungary	42.92
Ireland	0.3881	Greece	40.92
Hungary	0.3865	Latvia	40.82
Slovakia	0.3716	Ireland	40.59
Greece	0.3674	Slovakia	40.39
Poland	0.3502	Cyprus	39.62
Bulgaria	0.2960	Bulgaria	32.69
Romania	0.2543	Romania	28.12

The dendrogram below visualizes the groupings of nations in the clustering produced by the clustering analysis with the SPSS software. According to the tree graph (dendrogram) in Figure 3, it is seen that the nations are mostly clustered into three groups. The number of countries in the clusters obtained in the cluster analysis are shown in Table 9.

Table 9. Number of cases in each cluster

Cluster	1	7
	2	7
	3	15
Valid		29
Missing		0

The distances between the final cluster centers are displayed in Table 10. Consequently, it may be concluded that 2 and 3 are the two closest clusters, whereas 1 and 3 are the two furthest clusters. Additionally, Cluster 2 and Cluster 1 are closer than Cluster 3.

Table 10. Distances between final cluster centers

Cluster	*1*	*2*	*3*	*Cluster*
1		24.553	37.907	1
2	24.553		13.354	2
3	37.907	13.354		3

Table 11 indicates which countries relate to which clusters. Based on this data, it is possible to identify the shared characteristic of every cluster. France, Germany, Italy, and the Netherlands, for instance, are included in cluster 1. In light of this, cluster 1's common trait may be identified.

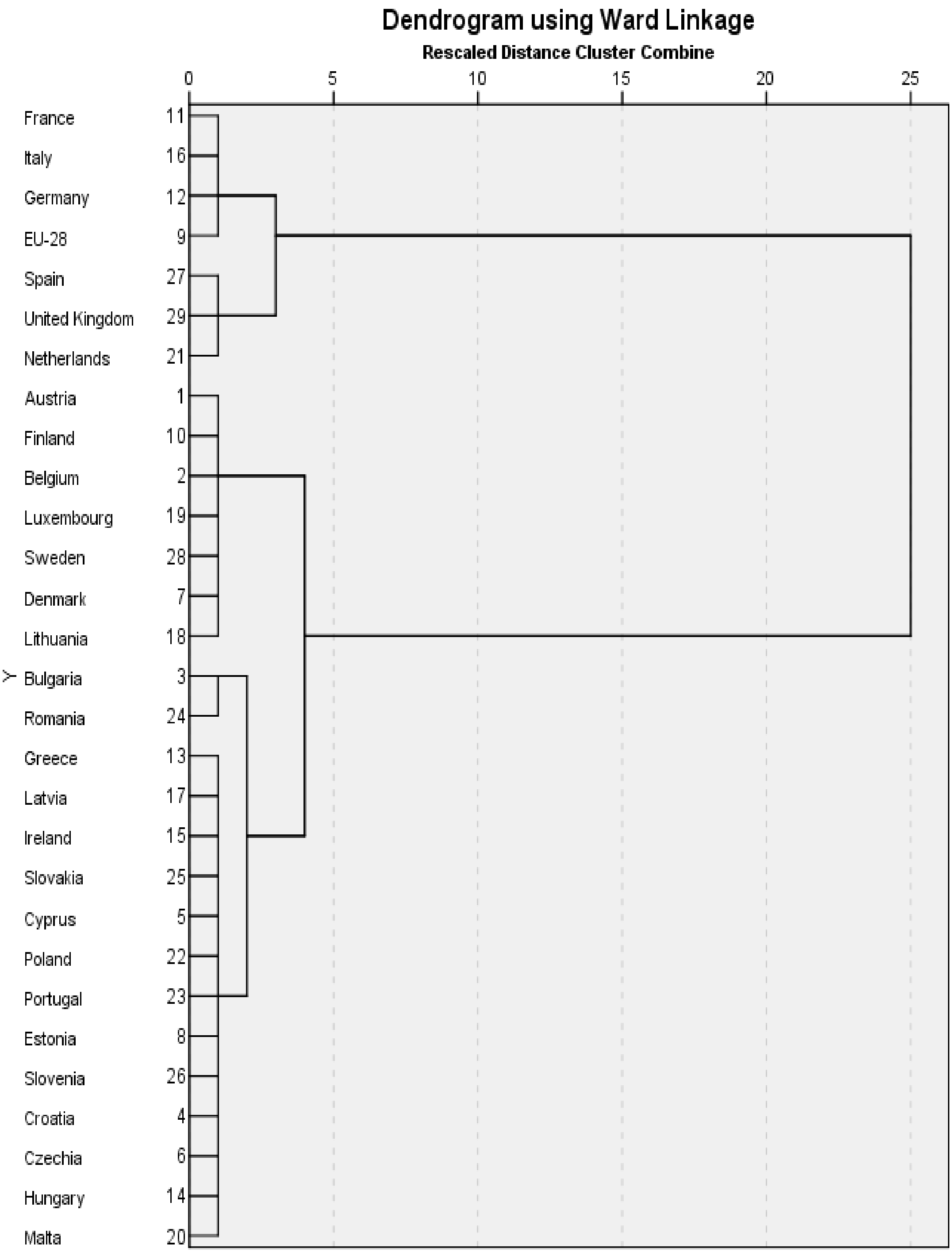

Figure 3. Dengrogram output of cluster analysis

Table 11 shows the benefit values generated from the COPRAS analysis using CRITIC weights, as well as the nation ranking created by sorting these values from greatest to smallest. According to the findings of this analysis, the Netherlands is in first place with a substantial difference, followed by the United Kingdom, Spain, EU-28 average, Germany, France and Italy, respectively. It is worth noting that these six nations are the most powerful economies of the European continent. On the other hand, when the end of the list is evaluated, Eastern European countries are at the bottom of the list.

The table also shows the benefit values generated from the MAUT analysis using CRITIC weights, as well as the nation ranking produced by sorting these values from greatest to smallest. According to the findings of this study, the Netherlands ranks top with a small difference, followed by the United Kingdom, EU-28 average, Spain, Denmark, Germany and France, respectively. Unlike the COPRAS ranking, Denmark is among the top seven instead of Italy. When looking towards the bottom of the list, Hungary, Slovakia, Greece, Poland, Bulgaria, and Romania are in the last rows.

Table 11. Cluster memberships of countries and ranking in terms of MAUT and COPRAS analysis

MAUT Method Ranking		*COPRAS Method Ranking*		*Cluster Membership*			
Countries	*Ui*	*Countries*	*Benefit Value (Nj)*	*Case Number*	*Countries*	*Cluster*	*Distance*
Netherlands	0.5610	Netherlands	100.00	1	EU-28	1	5.306
United Kingdom	0.5447	United Kingdom	87.29	2	France	1	9.016
EU-28	0.5378	Spain	81.19	3	Germany	1	7.446
Spain	0.5287	EU-28	73.92	4	Italy	1	9.036
Denmark	0.5258	Germany	71.78	5	Netherlands	1	20.774
Germany	0.5246	France	70.21	6	Spain	1	1.964
France	0.5234	Italy	70.19	7	United Kingdom	1	8.064
Luxembourg	0.5014	Denmark	58.08	8	Austria	2	2.163
Sweden	0.4890	Lithuania	56.98	9	Belgium	2	2.973
Italy	0.4697	Sweden	55.49	10	Denmark	2	3.408
Lithuania	0.4540	Luxembourg	54.71	11	Finland	2	1.433
Finland	0.4402	Finland	53.24	12	Lithuania	2	2.307
Estonia	0.4386	Austria	52.51	13	Luxembourg	2	0.050
Belgium	0.4367	Belgium	51.70	14	Sweden	2	0.817
Austria	0.4299	Malta	46.73	15	Bulgaria	3	8.630
Malta	0.4289	Slovenia	45.08	16	Croatia	3	2.681
Slovenia	0.4196	Estonia	44.91	17	Cyprus	3	1.699
Portugal	0.4012	Poland	44.69	18	Czechia	3	2.421
Czech Republic	0.3977	Portugal	44.57	19	Estonia	3	3.591
Cyprus	0.3963	Croatia	44.00	20	Greece	3	0.399
Latvia	0.3921	Czech Republic	43.74	21	Hungary	3	1.601
Croatia	0.3884	Hungary	42.92	22	Ireland	3	0.729
Ireland	0.3881	Greece	40.92	23	Latvia	3	0.500
Hungary	0.3865	Latvia	40.82	24	Malta	3	5.411
Slovakia	0.3716	Ireland	40.59	25	Poland	3	3.371
Greece	0.3674	Slovakia	40.39	26	Portugal	3	3.251
Poland	0.3502	Cyprus	39.62	27	Romania	3	13.200
Bulgaria	0.2960	Bulgaria	32.69	28	Slovakia	3	0.929
Romania	0.2543	Romania	28.12	29	Slovenia	3	3.761

Spearman Correlation analysis, a non-parametric approach, was used to assess the relationship between the scores and rankings obtained from the MCDM methods used in the study. When the values in Table 12 are evaluated, it is seen that there is a significant positive high correlation between all rankings.

Table 12. Spearman correlation analysis result

			MAUT	*COPRAS*
Spearman's rho	MAUT	Correlation Coefficient	0.955	0.945**
		Sig. (2-tailed)		0.000
		N	29	29
	COPRAS	Correlation Coefficient	0.945**	0.955
		Sig. (2-tailed)	0.000	
		N	29	29

Note: ** Correlation is significant at the 0.01 level (2-tailed).

5. DISCUSSION and CONCLUSION

Individual consuming patterns and habits can contribute to a variety of environmental issues, including decreased biological diversity, contamination of the environment and nature, increased CO_2 emissions, and global warming. These issues have begun to be examined, particularly in recent years. Excessive population expansion and rapid economic development are seen as the primary causes of these arguments. However, the rise in personal quality of life, cultural shifts like urbanization and women entering the workforce, the emergence of globalized economic systems driven by economies of scale, the decline in product prices, and the rise of environmental issues have brought the current discussions to the forefront. However, the environmental benefits of initiatives to improve the efficiency and cleanliness of manufacturing processes are being undermined by unsustainable population expansion and the rise in individual demands for the consumption of products and services.

Combining environmental sustainability with economic growth and prosperity by separating environmental degradation from economic expansion and using less resources is one of the largest global issues. In order to encourage sustainable patterns of production and consumption and facilitate the shift to a more environmentally friendly and socially inclusive global economy, resource and impact decoupling are crucial. Respecting the planet's biophysical constraints and lowering global consumption rates to make them consistent with the biophysical capacity to provide ecosystem services and benefits are essential for maintaining sustainable production and consumption practices.

Sustainable production and consumption are linked to improved living standards for everybody. Overall development objectives are achieved, future economic, environmental, and social costs are decreased, economic competitiveness is raised, and poverty is decreased. This means that every link in the supply chain, from the producer to the merchants, needs to collaborate in an organized way. It entails informing consumers about sustainable lifestyles and consumption, giving them accurate information through standards and labeling, and participating in sustainable public procurement. In this attempt, industry, consumers, legislators, academia, merchants, the media, and development cooperation groups should come together to build a new global coalition.

The research article assesses 28 European nations using 22 metrics and three circular economy characteristics. In order to further this topic, the article also seeks to provide an integrated decision-making approach in addition to illustrating the existing condition of these nations.

Following the examination of the dendrogram in cluster analysis, it was determined to split the nations into three categories using K-means cluster analysis. We are able to observe nations that have similar standards in this way.

Upon analyzing the nations inside the groups produced by the K-means clustering technique, it becomes evident that the nations with comparable scores in the rankings produced by the CRITIC-weighted MAUT and COPRAS techniques are gathered within the same clusters. The outcomes of the clustering analysis using both MCDM ranks and the data mining classification approach have thus far been found to be quite consistent. Additionally, the consistency of the analysis's findings was evaluated using the Spearman correlation method.

The six nations that make up the first cluster in the cluster analysis—France, Germany, Italy, the Netherlands, Spain, and the United Kingdom—are also the top six nations in the COPRAS rating. Rather than Italy, Denmark is ranked in the top six on the MAUT ranking list.

The countries included in the MCDM rankings and cluster analysis almost overlap when COPRAS and MAUT values and rankings based on scores are compared with the second cluster of cluster analysis; however, the results of cluster analysis and MAUT analysis are consistent, with the exception of Denmark and Estonia.

Austria, Belgium, Denmark, Finland, Lithuania, Luxembourg, Sweden, and Estonia, which closely trail the top six nations, are classified in the same category by Circular Economy metrics, according to the overall assessment of the data. The following countries are in the same cluster: Bulgaria, Croatia, Cyprus, Czechia, Greece, Hungary, Ireland, Latvia, Malta, Poland, Portugal, Romania, Slovakia, and Slovenia based on how well they performed in the circular economy. These are the countries that scored the lowest on certain indicators and were ranked lowest among those evaluated for the analysis.

A brief part has been presented on what the Netherlands, which has the best scores in majority of the studies in the literature, has done to promote the circular economy. The Dutch government collaborates with other public authorities, knowledge institutes and environmental groups, industry, trade unions, financial institutions, and other civil-society organizations to develop smarter and more efficient methods of using raw resources. By 2050, the objective is for the Dutch economy to be totally circular. The first priority is to reduce the use of basic raw resources by half by 2030. Clearly, these national objectives are connected to international objectives to which the Netherlands has committed, such as the Sustainable Development Goals for 2030 and the Paris Agreement on climate. The government has established three objectives designed to make the Dutch economy circular as soon as possible (Marino & Pariso, 2020; Walker et al., 2021):

- Ensure that industrial processes use raw resources more effectively, so that less are required.
- When new raw materials are required, employing sustainably generated renewable (inexhaustible) and readily accessible raw resources, such as biomass - a raw material comprised of plants, trees, and food waste. This may reduce the reliance on fossil fuel supplies of Netherlands, which is environmentally preferable.
- Developing novel circular manufacturing processes and designs for circular goods.

In conclusion, more research on these and related topics is expected to lead to the development of more sensible policies and a rise in public understanding of the problems pertaining to sustainable production and consumption as well as the circular economy, which is an essential part of the world's efforts to achieve sustainable economic development. To guarantee a sustainable standard of living, many nations require investments as well as policies for sustainable production and consumption.

Balkan and Eastern European countries are typically ranked lowest on the list. The outcomes of these analyses and methodologies provide businesses and governments with a strategic comparison tool with regard to environmental and circular economy goals. This research is anticipated to increase public knowledge of the circular economy and its benefits for the sustainable economy and environment. The outcomes of this approach will be contrasted with those of subsequent studies that employ different methodologies. It is expected that in future studies, different dimensions will be added to the circular economy assessment, analyzed with other methods and compared with the results of this study.

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Compliance with Ethical Standards
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It was declared by the author that scientific and ethical principles have been followed in this study and all the sources used have been properly cited.

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