**International Journal of Management and Sustainability**
*2020 Vol. 9, No. 4, pp. 207-217.*
*ISSN(e): 2306-0662*
*ISSN(p): 2306-9856*
*DOI: 10.18488/journal.11.2020.94.207.217*


# CONTEMPORARY PARADIGM OF SUSTAINABLE DEVELOPMENT IN THE EUROPEAN UNION

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**Article History**
Received: 6 August 2020
Revised: 24 August 2020
Accepted: 9 October 2020
Published: 27 October 2020

**Keywords**
Sustainability
European Union
R&D expenditure
Environmental assessment
Quantitative analysis
Economic growth
Indicators.

## ABSTRACT

This study aims to explore the level of sustainable development in the European Union and examines the relationship that may exist between the sustainability index and the population of its member states, the GDP per capita, and the investments made in R&D. Furthermore, it aims to explore the role of the geographical region as a determining factor in the performance of these countries in each sustainability dimension. The research methodology employs a quantitative approach supported by the adoption of simple and multiple linear regression, cluster analysis, and variance analysis (ANOVA). The findings reveal that R&D expenditure is mainly a determining factor in a country's sustainable performance. Moreover, it has been possible to identify several asymmetries, with geographical region emerging as a determining factor in the performance of European Union countries in 11 of the 17 dimensions of sustainability. This work offers both theoretical and practical contributions. From the theoretical perspective, it explores the relationship between sustainability and investments in R&D, GDP per capita, and population. From a practical point of view, it offers relevant information to be used by European Union countries to establish supportive policies to enhance the sustainability of economic growth.

**Contribution/Originality:** This study contributes to the existing literature by exploring the current state of sustainable development in the European Union (EU). The aim is to assess the relevance of multiple dimensions such as population, GDP per capita, and R&D investments in the sustainable development performance of the EU member countries.

## 1. INTRODUCTION

The search for a more sustainable model of society's evolution has been a dominant concern in recent decades. Economic development has brought a variety of opportunities, but also threats, that affect the structure of economic activities, the society, and the environmental balance. Bradshaw, Giam, and Sodhi (2010) state that the constant population increase, coupled with the growth in consumption of non-renewable resources, has generated strong implications for our way of life (e.g., the increase in pollution and climate change).

The concept of sustainable development gained greater prominence with the Brundtland Report proposed in 1983, which explores the concept of sustainable development from a multidisciplinary perspective that includes the role of the international economy, human resources, industry, energy, species and ecosystems, among others (WCED, 2020). This document is also a fundamental reference in the search for a definition for sustainable development, in which this concept is defined as "development that meets the needs of the present without

compromising the ability of future generations to meet their own needs" (WCED, 2020). This approach demonstrates the need for an integrated and balanced holistic vision of the three pillars of sustainable development (i.e. economic, social, and environmental). This report has been a cornerstone in the evolution of this phenomenon and has encouraged the complex pursuit of sustainability in the various human activities. Furthermore, and according to Holden, Linnerud, and Banister (2014) it also contributed to the search for a social and economic model that enhances harmony with the environment. Sustainability can take several dimensions. Economic sustainability considers the need to generate prosperity at different levels of society and turn economic activity efficient (Spangenberg, 2005). This ensures that the activities of organizations are viable and contribute to wealth generation and employment promotion. Respect for human rights and equal opportunities for all individuals are considered in social sustainability (Ajmal, Khan, Hussain, & Helo, 2018). This builds a more equitable society, with social inclusion and distribution of goods to eliminate poverty. In turn, environmental sustainability considers the conservation and management of natural resources, especially those that are not renewable and are fundamental to life support (Little, Hester, & Carey, 2016). Consequently, it becomes indispensable to develop actions to preserve biological diversity and minimize air, water and soil pollution. As Newsroom (2019) states, the concept of sustainable development implies setting limits on the exploitation of environmental resources and depends on the planet's capacity to absorb the effects of human activities. The path that each country needs to take to achieve sustainability is not necessarily the same. Each country must adapt to its needs and problems. In this sense, this study seeks to explore the current state of sustainable development in each European Union (EU) country considering its multiple dimensions and also to evaluate the role of country-specific factors in determining the sustainable development performance of EU member states. This study is organized as follows: In the first phase, a literature review is carried out on the concept of sustainability and sustainable development. Next, the study methodology and associated methods are presented. After that, the results of this study are reported and discussed considering its effects on the sustainability index. Finally, the main conclusions are drawn, and some items for future work are also suggested.

## 2. LITERATURE REVIEW

Economic growth has been the solution to the problems of countries' low competitiveness and as a key element in reducing or eliminating poverty (Sinding, 2009). However, looking at this indicator alone is clearly incoherent and inconsistent. Economic indicators like GDP or GDP per capita need new measures to determine the level of development of nations more accurately. As Machado and Mata (2015) advocate, economic growth alone has become insufficient to guarantee the development of countries. Nowadays, growth must include other components, like the socio-environmental dimension. Therefore, and in parallel with concerns related to social indicators for assessing a country's level of development, environmental issues have also come to be considered. In this way, the concept of sustainable development has gradually become a relevant indicator to reveal the level of development of a country (Filho et al., 2019; Villeneuve, Tremblay, Riffon, Lanmafankpotin, & Bouchard, 2017).

Raising the standard of living of a country is necessarily one of the priority political objectives. Coyle (2015) stresses the importance of GDP growth in improving the living standards of the population. Therefore, two of the main measures used to analyze economic growth are the GDP growth rate and GDP per capita. The first refers to the annual development of GDP, while the second can be calculated by dividing GDP by the total population.

Several authors such as Tol (2018) and Zuo and Ai (2011) point out that economic growth also brings some costs, namely environmental degradation, which is responsible for affecting the quality of life of the population. GDP is an indicator to measure economic activity and looks at the set of all goods and services produced in a country. However, it does not look at levels of development in areas such as health, education, among others. Furthermore, Van den Bergh (2011) states that other elements such as environmental quality and the depletion of natural resources are not considered in GDP per capita. Consequently, and as Giannetti, Agostinho, Almeida, and

Huisingh (2015) point out, GDP is a weak indicator to analyze countries' performance. From this fragility becomes evident the conceptual differences between growth and development. Economic growth, although necessary, assumes only an instrumental role. Sachs (2015) stresses that development cannot take place without growth; however, growth does not in itself guarantee the development of a country. Indeed, growth can go together with increasing social inequalities, increasing poverty rates, and unemployment levels. Therefore, elements like equality and solidarity must be linked to the concept of development (Sachs, 2015). From this proposal, a country's goal should not only be to maximize GDP or GDP per capita, but also to promote equality and improve the living conditions of the population, particularly among the most vulnerable social classes.

The neoclassical economic theory that supported quantitative growth models based on the maximization of GDP does not adequately address the simultaneity of economic, social, and environmental objectives. In fact, and as Sachs (2015) states, these models disregard that natural resources are finite. Moreover, this approach promotes the concentration of power and natural resources, stimulates inequalities, and devastates the environment (Blewitt, 2017). Consequently, it is necessary to find a new way of measuring economic progress, with the emergence of endogenous growth theory. This perspective considers that growth must be sustained from multiple perspectives, in which economic development, technological progress, natural resources, and human development are considered (Blewitt, 2017). In the literature on sustainable development, there is a broad definition of this concept. Teodorescu (2015) presents sustainability as a multidimensional concept where economic, social, and environmental aspects must be integrated. Beekman (2004) states sustainable development is a development model that allows the needs of the present to be met without compromising the ability of future generations to meet their own needs. Feil and Schreiber (2017) complement this vision by emphasizing that sustainable development presupposes enabling people, now and in the future, to achieve a satisfactory level of socio-economic and cultural development, making reasonable use of natural resources so as not to deplete them for future generations. Despite the wide diversity of definitions, it is common to find common principles based on economic development, social development, and environmental conservation. Another definition of sustainable development based on a multidimensional perspective is given by Sachs (2015) in which sustainable development is based on five pillars: (i) social, in which the risks of rupture and the emergence of social inequalities must be considered; (ii) environmental, due to the importance of natural resources that are scarce and must be managed; (iii) territorial, in which the distribution of resources among populations is looked at; (iv) economic, where economic viability is considered an indispensable condition; and (v) political, where governance is a necessary instrument for the functioning of the system.

The concepts of sustainable development and sustainability move together and are often addressed jointly. However, these two concepts must be distinguished. While sustainability fundamentally covers issues related to environmental degradation and pollution, the focus of sustainable development is essentially on the planned and participatory development of a new economic and civilizing organization that ensures the future of future generations (Blewitt, 2017). The way the concept of sustainable development is viewed has evolved over the past decades as a result of the evolution of scientific knowledge and increased awareness in society. The eight sustainability goals defined for the period from 2000 to 2015 gave rise to the 17 sustainable development goals from 2015 onwards (UN, 2019). This agenda aims to create a new global model to end poverty, promote prosperity and well-being, protect the environment, and combat climate change. The 17 sustainable development goals include: (i) no poverty; (ii) zero hunger; (iii) good health and well-being; (iv) quality education; (v) gender equality; (vi) clean water and sanitation; (vii) affordable and clean energy; (viii) decent work and economic growth; (ix) industry, innovation, and infrastructure; (x) reduced inequalities; (xi) sustainable cities and communities; (xii) responsible consumption and production; (xiii) climate action; (xiv) life below water; (xv) life and land; (xvi) peace, justice, and strong institutions; and (xvii) partnerships for the goals.

## 3. METHODOLOGY

### *3.1. Data*

Data from this study are obtained from the European Union, in concrete from the 2019 Europe Sustainable Development Report (EU, 2019). This report compares the performance of the 28 EU member states according to all 17 SDGs established by the United Nations on the Sustainable Development Goals (UN, 2019). The country's performance is measured on a scale of 0 to 100, on which the maximum value means that all SDGs have been achieved. Furthermore, a color scheme is used by the EU to better identify each country's performance. The following scale was applied: (i) red, major challenges; (ii) orange, significant challenges; (iii) yellow, challenges remain; and (iv) green, goal achievement. In a first step, the dataset was downloaded to retrieve the overall performance of each country (i.e., EU SDG Index Score) and the specific performance for each of the 17 SDGs, considering the last available year (i.e. 2019) as a reference. The code for each color has been mapped on a scale of 1 to 4 to perform statistical analysis of the data. Furthermore, the following information was collected for each country:

- Population – the population living in each European Union country.
- GDP per capita – measures how much of the total produced is for each citizen if all had equal shares. It is calculated based on the GDP in the calendar year to be divided by the average resident population.

The gross domestic expenditure on R&D for each European member state was also obtained. These data were collected from the Eurostat database. R&D expenditure is defined by Eurostat (2019) as: "Research and experimental development (R&D) comprise creative work undertaken on a systematic basis to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications. R&D expenditures include all expenditures for R&D performed within the business enterprise sector (BERD) on the national territory during a given period, regardless of the source of funds. R&D expenditure in BERD is shown as a percentage of GDP (R&D intensity)." Figure 1 shows a comparative analysis of the performance of European member states in the Sustainable Development Index (SDI). On average the European Union's performance is 70.1. At the top of the list are countries such as Denmark, Sweden, and Finland, while the last three places are occupied by Bulgaria, Romania, and Cyprus. 12 countries also perform above the European average, while 16 countries are below the European average. The standard deviation of European performance is 6.857, indicating a relatively asymmetric performance between countries.

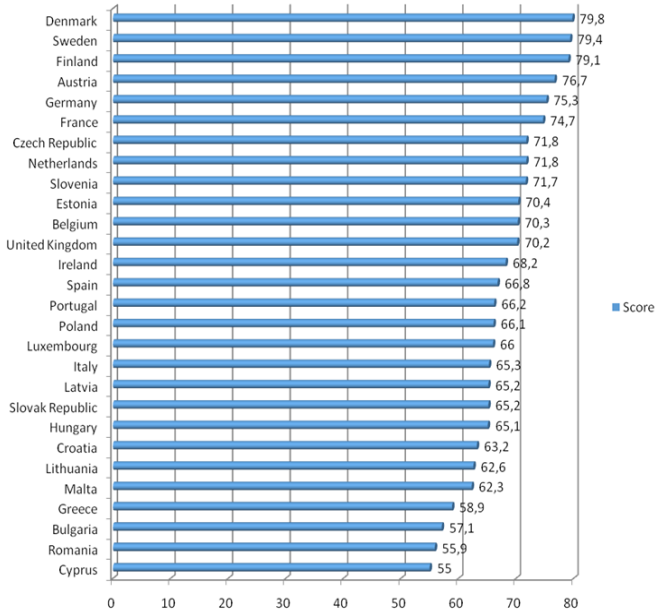


**Figure-1.** Ranking of EU member states according to EU SDG Index 2019.

Finally, the data were grouped into five geographical areas and their performance was measured, as shown in Table 1. The performance of the Northern Europe countries is identical and superior to the other countries. The largest dispersion of country performance in the EU SDG Index is recorded for countries in Central and Eastern Europe, followed by Southern Europe. It is also clear that the worst performing regions are those with the highest performance asymmetry of their countries.

**Table-1.** Performance analysis by geographic region.

| Region | Country | Score (mean) | Score (std. dev.) |
|---|---|---|---|
| Baltic States | Estonia, Latvia, Lithuania | 66.1 | 4.0 |
| Central and Eastern Europe | Czech Republic, Slovenia, Poland, Slovak Republic, Hungary, Croatia, Bulgaria, Romania | 64.5 | 5.8 |
| Northern Europe | Denmark, Sweden, Finland | 79.4 | 0.4 |
| Southern Europe | Spain, Portugal, Italy, Malta, Greece, Cyprus | 62.4 | 4.7 |
| Western Europe | Austria, Germany, France, Netherlands, Belgium, United Kingdom, Ireland, Luxembourg | 71.7 | 3.7 |

### *3.2. Methods*

This study adopts a quantitative methodology to analyze the impact of several independent variables on the sustainability indexes of the European Union countries. The quantitative research is a statistical study that aims to characterize and describe the characteristics of a given occurrence. To this end, data are evaluated quantitatively considering the assumptions made regarding a research problem. Queirós, Faria, and Almeida (2017) highlight this approach also enables exploring the robustness and reliability of the obtained findings. Furthermore, Render, Stair, Hanna, and Hale (2014) advise that research questions should be objective and easily quantifiable.

The SPSS v.21 was used to explore the relationships between the data and by offering several statistical methods of correlational analysis between the data. The following statistical methods were applied:

- Simple and multiple linear regression – seeks to explore the relationship between two or more variables in such a way that one variable can be predicted from the other(s). The simplest case of regression is when we have two variables and the relationship between them can be represented by a straight line (Judd, McClelland, & Ryan, 2017). Finally, Zhang (2016) recommends the adoption of the coefficient of determination to measure the confidence placed in the regression equation as a measurement instrument. Therefore, an $R^2$ close to zero indicates a linear model that is very unsuitable and an $R^2$ close to 1 means that we have a linear model that is very adequate.
- Clusters analysis – an exploratory technique of multi-variable data analysis that allows classifying a set of categories into homogeneous groups, observing the similarities or dissimilarities between them (Everitt, Landau, Leese, & Stahl, 2011). Mahalanobis distance is used to take into account the correlations of the dataset.
- Variance analysis (ANOVA) – a method for testing the equality of three or more population means, based on the analysis of sample variances (McClave, Benson, & Sincich, 2017). The data were grouped considering the region of each country.

## 4. RESULTS AND DISCUSSION

### *4.1. Performance in the EU SDG Index*

In the first stage, the relationship between the three independent variables of the model (i.e. population, GDP per capita, and R&D expenditure) and the EU SDG Index was explored. For this purpose, a simple linear regression was performed, as shown in Table 2. Some interesting conclusions can be drawn, namely: (i) there is a strong positive correlation between R&D expenditure and the EU SDG Index, this being the strongest relationship identified in the model; (ii) the weight of the correlation between GDP per capita and the EU SDG Index is

moderately positive, which is lower than the existing relationship considering R&D investments; (iii) the correlation with the independent variable of the population is weak; and (iv) there is a moderate correlation between R&D expenditure and GDP per capita, which indicates that the countries with the highest per capita income index are also those with the best conditions to make R&D investments.

**Table-2.** Simple linear regression.

| Variables | EU SDG Index | R&D expenditure | Population | GDP per capita |
|---|---|---|---|---|
| EU SDG Index | 1 | 0.895 | 0.243 | 0.533 |
| R&D expenditure | | 1 | 0.337 | 0.485 |
| Population | | | 1 | -0.077 |
| GDP per capita | | | | 1 |

The strong relationship between R&D investments and sustainability is also mentioned by Fernández, López, and Blanco (2018) in which it is shown that R&D spending can contribute doubly in two areas. On the one hand, and as also argued by Kokko, Tingvall, and Videnord (2015) R&D investment contributes to the growth of the European Union economy. Moreover, it can also act as a key element for sustainable development through the reduction of CO2 emissions. However, its role, and as the results of this study demonstrate, can be more comprehensive, with R&D investments playing a key role in increasing the sustainability of European Union countries. In the second phase, this study explored the multiple linear relationships between the two independent variables that exhibit a significant positive correlation (i.e., strong or moderate). In this sense, the independent variables R&D expenditure and GDP per capita were chosen. The information in Table 3 concludes that there is a strong correlation between the variables of the model. The Adjusted R Square was calculated considering the reduced number of data (i.e. 28 countries) and to compensate the effect of several predictors. Johnson (2015) states this approach allows compensating for the addition of variables and only increases if the new predictor improves the model above what would be obtained by probability. Furthermore, Sig. F. Change indicates a good fit of the model and the Durbin-Watson value allows the conclusion that there is no dependency between wastes, i.e. no correlation between successive residuals (i.e., d ∈ ⌈du, 4-du⌈ ).

**Table-3.** Multiple linear regression.

| R | R Square | Adjusted R Square | F Change | Sig. F. Change | Durbin-Watson |
|---|---|---|---|---|---|
| 0.902 | 0.814 | 0.799 | 54.734 | $<1.10^{-3}$ | 1.625 |

A cluster analysis was carried out in a 3rd stage considering the country profile considering the independent variables R&D expenditure and GDP per capita. Table 4 shows the result presented by SPSS software on the distribution of clusters and the difference between the final clusters. Five clusters were created with the following distribution: (i) Cluster 1 contains two countries (i.e. Finland, and Belgium); (ii) Cluster 2 contains eight countries (i.e. Lithuania, Latvia, Bulgaria, Czech Republic, Romania, Slovak Republic, Cyprus, and Italy); (iii) Cluster 3 contains five countries (i.e. Croatia, Slovenia, Germany, Luxembourg, and Netherlands); (iv) four countries are placed in Cluster 4 (i.e. Denmark, Sweden, Austria, and France); and (v) nine countries are placed in Cluster 5 (i.e. Estonia, Hungary, Poland, Spain, Greece, Malta, Portugal, United Kingdom, and Ireland). More than 60% of countries are in Cluster 2 and 5. The countries with the highest GDP per capita and R&D expenditure are also those with the highest EU SDG Index, although there are some exceptions, such as Belgium, which despite belonging to Cluster 1 is not in the top ten of the sustainability index, or Germany, which is not in Cluster 1 or 3, is in 5th place on the sustainability index.

**Table-4.** Cluster analysis.

| | Final Cluster Centers | | | | |
|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** |
| GDP per capita | 4.619 | 4.428 | 4.576 | 4.663 | 4.562 |
| R&D expenditure | 2.670 | 0.688 | 1.898 | 3.143 | 1.221 |
| Cluster | Distance between final cluster centers | | | | |
| 1 | - | 1.992 | 0.773 | 0.475 | 1.450 |
| 2 | 1.992 | - | 1.220 | 2.466 | 0.550 |
| 3 | 0.773 | 1.220 | - | 1.248 | 0.677 |
| 4 | 0.475 | 2.466 | 1.248 | - | 1.924 |
| 5 | 1.450 | 0.550 | 0.677 | 1.924 | - |

### *4.2. Performance in Specific SDGs*

The performance of the European Union and its member states was also analyzed considering the 17 specific sustainability goals. Table 5 provides a brief statistical analysis of the European Union's performance considering some key metrics such as average, median, standard deviation, skewness, and kurtosis. The performance on each dimension is measured according to a discrete scale of four values, respectively: (i) 1 - major challenges remain; (ii) 2 - significant challenges remain; (iii) 3 - challenges remain; and (iv) 4 - SDG achieved. The indicators in which the European Union offers the best performance are no poverty, decent work and economic growth, and good health and well-being. Despite this, none of these three dimensions achieves the 3 values average, which means that several challenges persist in some countries in the European Union. For example, in the case of Romania, the fight against poverty still has a long way to go. According to the Niklasson (2019) more than one-third of children lives below the poverty line in Romania, with a large proportion of them still having access to basic rights between urban and rural areas. In terms of access to employment, there are also considerable asymmetries in the unemployment rate (UR), particularly in countries such as Greece (e.g. UR=16.5%), Spain (e.g. UR=13.7%), Italy (9.8%) in December 2019 (EC, 2020). This situation has an impact on both the economic growth of these countries and has serious psychological effects as reported by Zechmann and Paul (2019). On the opposite side, the lowest performance in the European Union is in responsible consumption and production, and life below water dimensions. In both areas, there are very low performances from all countries. Responsible consumption and production are understood as the ability of countries to meet their present needs without compromising the ability of future generations. Allen, Bas-Defossez, and Weigelt (2018) state that consumes it and produces products is an area where the European Union takes on several challenges and is responsible for environmental problems such as water, air, and soil pollution. Also, in the "life below water" dimension, there are still notable difficulties, with Milo-Dale (2020) highlighting that the European seas are not sufficiently healthy and resilient. Another factor highlighted by Milo-Dale (2020) is the capture of fish that threatens marine ecosystems.

Skewness analysis enables the exploration of symmetry of the distribution. The most asymmetric distributions occur for "zero hunger", "clean water and sanitation", and "life below water" dimensions. In the first two dimensions, we have negative asymmetrical distributions, while in the latter we have positive asymmetry. The kurtosis is also relevant above all in the analysis of the behavior of the curve due to the eventual existence of outliers. As kurtosis is less than 3, we are in the presence of a platykurtic distribution, indicating the absence of outliers. Finally, looking at the standard deviation, we can identify that essentially in "Industry innovation and infrastructure" there are remarkable asymmetries between the European Union countries, namely the southern European countries (e.g. Portugal, Greece, Spain) show performances significantly below those of Northern Europe and Western Europe (e.g. Finland, Denmark, Germany).

**Table-5.** Statistical analysis of specific sustainability goals.

| Dimension | Mean | Median | Std. dev. | Skewness | Kurtosis |
|---|---|---|---|---|---|
| No poverty | 2.86 | 3 | 0.848 | -0.104 | -0.800 |
| Zero hunger | 1.75 | 2 | 0.441 | -1.221 | -0.554 |
| Good health and well-being | 2.64 | 3 | 0.559 | 0.070 | -0.738 |
| Quality education | 2.39 | 2 | 0.685 | 0.045 | -0.002 |
| Gender equality | 2.25 | 2 | 0.585 | -0.075 | -0.291 |
| Clean water and sanitation | 2.50 | 3 | 0.793 | -0.719 | -0.243 |
| Affordable and clean energy | 2.25 | 2 | 0.752 | 0.669 | 0.703 |
| Decent work and economic growth | 2.71 | 3 | 0.879 | -0.372 | -0.397 |
| Industry innovation and infrastructure | 2.39 | 2 | 1.197 | 0.273 | -1.468 |
| Reduced inequalities | 2.54 | 3 | 0.761 | -0.140 | -0.096 |
| Sustainable cities and communities | 2.32 | 2 | 0.670 | -0.479 | -0.642 |
| Responsible consumption and production | 1.46 | 1 | 0.508 | 0.151 | -2.135 |
| Climate action | 1.50 | 1.50 | 0.509 | 0 | -2.160 |
| Life below water | 1.48 | 1 | 0.593 | 0.806 | -0.218 |
| Life on land | 1.64 | 2 | 0.678 | 0.586 | -0.615 |
| Peace, justice, and strong institutions | 2.50 | 2.50 | 0.638 | 0 | -0.089 |
| Partnerships for the goals | 2.14 | 2 | 0.803 | 0.650 | 0.525 |

Finally, it was sought to explore the relevance of each country's geographical region in the light of their performance in the various dimensions that compose the sustainability index. For this purpose, an analysis of variance (ANOVA) was carried out adopting a significance level of 5% ($\alpha = 0.05$). The results of this analysis are available in Table 6. It was proven that in 11 of the 17 dimensions, the geographic region is a determining factor in explaining the countries' behavior. It is evident that in the dimensions where significant differences occur, the performance of Northern European countries is relatively systematically superior except for life on land dimension. This dimension intends to look at the sustainable use of terrestrial ecosystems, particularly by combating desertification and managing forests in a sustainable way. Here there is a clearly better behavior of the Baltic countries. Although existing information in this field is quite scarce, a study conducted by Kurlavicius et al. (2004) indicated that on average 17% of forests in the Baltic countries had a high conservation value for maintaining forest biodiversity.

**Table-6.** Exploring the impact of the geographic region.

| Dimension | Region | | | | | Sig. |
|---|---|---|---|---|---|---|
| | BS | CE | NE | SE | WE | |
| No poverty | 2.00 | 2.75 | 3.67 | 2.50 | 3.25 | 0.054 |
| Zero hunger | 1.67 | 1.88 | 2.00 | 1.50 | 1.75 | 0.482 |
| Good health and well-being | 2.00 | 2.38 | 3.33 | 2.50 | 3.00 | 0.001 |
| Quality education | 2.67 | 2.13 | 3.33 | 2.00 | 2.50 | 0.034 |
| Gender equality | 2.00 | 2.00 | 3.00 | 1.83 | 2.63 | 0.003 |
| Clean water and sanitation | 1.67 | 2.38 | 3.33 | 2.17 | 2.88 | 0.031 |
| Affordable and clean energy | 2.00 | 2.25 | 3.67 | 1.83 | 2.13 | 0.003 |
| Decent work and economic growth | 3.00 | 2.50 | 4.00 | 2.00 | 2.88 | 0.014 |
| Industry innovation and infrastructure | 1.67 | 1.75 | 3.67 | 1.33 | 3.63 | $<1.e^{-3}$ |
| Reduced inequalities | 1.33 | 2.50 | 3.67 | 2.00 | 2.88 | $<1.e^{-3}$ |
| Sustainable cities and communities | 2.67 | 1.88 | 3.00 | 1.67 | 2.88 | $<1.e^{-3}$ |
| Responsible consumption and production | 1.67 | 1.75 | 1.67 | 1.17 | 1.25 | 0.128 |
| Climate action | 1.33 | 1.48 | 1.67 | 1.33 | 1.75 | 0.474 |
| Life below water | 2.00 | 1.80 | 1.00 | 1.33 | 1.33 | 0.159 |
| Life on land | 3.00 | 1.75 | 1.67 | 1.33 | 1.25 | $<1.e^{-3}$ |
| Peace, justice and strong institutions | 2.67 | 2.38 | 2.67 | 2.67 | 2.38 | 0.860 |
| Partnerships for the goals | 2.00 | 2.13 | 3.67 | 1.83 | 1.88 | 0.004 |

Nevertheless, even considering the Baltic countries, there is still a long way to go in preserving forests and promoting biodiversity despite the emergence of innovative pilot projects in this field (Hämäläinen, Strengbom, & Ranius, 2020; Sánchez-Almendro, Hidalgo, Galán, Carrasco, & López-Tirado, 2018). Currently, the main challenges

related to the drastic reduction of biodiversity in forests are related to intensive agricultural practice, increasing urbanization, forest destruction, pollution, among other human factors (Vizzarri, Tognetti, & Marchetti, 2015).

## 5. CONCLUSIONS

Sustainability is a concept related to sustainable development that enables the exploration of ecologically correct, economically viable, socially just, and culturally diverse attitudes. Sustainability serves as an alternative to ensure the survival of the planet's natural resources while providing human beings and societies with ecological solutions for development. Sustainability is an area in which the European Union has devoted strong attention and sustainable growth is one of the main goals of the European Union.

This study sought to explore the relationship between the population, GDP per capita, and R&D expenditure and the sustainable development index in the European Union. The findings revealed that R&D expenditure has a strong positive correlation with the sustainability index, while GDP per capita has only a moderate positive effect. On the contrary, the population is a non-determining variable in the performance of the European Union countries. In this sense, it is evident that the countries that make the greatest investments in R&D are those that will have the best conditions for sustainable development. There are notable asymmetries in the behavior of the European Union considering the 17 indicators of the sustainability index. The dimensions in which the European Union performs better are in the fight against poverty, decent work and economic growth, and good health and well-being. Despite this positive performance, there are still significant asymmetries in the performance of some countries in these indicators. On the opposite side, the worse performances are recorded in responsible consumption and production, and life below water dimensions. In these indicators, the overall performance of countries is quite similar and there are no countries that stand out clearly in a positive way concerning the others. Furthermore, this study was important in identifying significant asymmetries in behavior between countries in these 17 indicators considering their geographical region. This is a factor that impacts 11 of the 17 dimensions of the sustainability index.

This study offers unequivocal theoretical and practical contributions. From a conceptual point of view, it has been possible to explore the relationship between sustainability and investments made in R&D, the GDP per capita and the population of each European Union country. In the practical dimension, the results of this study are relevant for the European Union and its member states to establish supportive public policies that reconcile economic growth and the preservation of sustainability. Two main limitations can be pointed out in this study. Firstly, factors specific to each country's development are not considered. Moreover, the study does not perform a longitudinal analysis of the evolution of sustainability indices, nor does it monitor the impact of the public policies established by the European Union and its member states on each dimension of sustainability. Consequently, and as future work, it is intended to build a framework to explore the specific factors of each country and monitor over several years the evolution of the performance of countries in the various dimensions that compose the sustainability index.

**Funding:** This study received no specific financial support.
**Competing Interests:** The authors declare that they have no competing interests.
**Acknowledgement:** Both authors contributed equally to the conception and design of the study.

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