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Towards the 2030 Agenda: Measuring the Progress of the European Union Countries through the SDGs Achievement Index

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Abstract: The 2030 Agenda and Sustainable Development Goals were adopted by the United Nations in 2015 as a universal call to action to end poverty, protect the planet, and ensure that by 2030 all people enjoy peace and prosperity. The success or failure in their implementation largely depends on the national implementation effort, measured within wide and compound indicator frameworks. Due to such complexity, providing a simple but comprehensive view on the progress to achieve the SDGs is a priority. Moreover, the measure of the progress allows the consistency among the different dimensions of sustainable development to be assessed. The purpose of this work is to evaluate the results accomplished by European Union Countries in achieving SDGs. In particular, the paper proposed the SDGs achievement index (SDG-AI), a multicriteria-based index, including six different dimensions and applied to EU countries. The SDG-AI allows the differences across the EU countries to be highlighted, and also assesses the contribution of the different dimensions to the final result. The use of such an index will also be useful to understand the effect of the pandemic on the development.

Keywords: sustainable development goals; sustainable development goals achievement index; agenda 2030; sustainable development

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1. Introduction

Agenda 2030 is a plan of action for people, planet and prosperity. It also seeks to strengthen universal peace in larger freedom. The eradication of poverty in all its forms and dimensions, including extreme poverty, is the greatest global challenge and an indispensable requirement for sustainable development [1].

The definition of sustainable development was first introduced in the Brundtland report by the World Commission on Environment and Development (WCED) in 1987 (United Nations), and it is the most widely used. The milestones in the international pursuit of sustainable development, which paved the way for the 2030 Agenda, are as follows: the Rio Declaration on Environment and Development (1992), the World Summit for Social Development (1995), the Programme of Action of the International Conference on Population and Development (ICPD) (1994), the Beijing Platform for Action (1995), the Millennium Declaration (from which the Millennium Development Goals were derived), the World Summit on Sustainable Development (2002), the 2005 World Summit outcome, and the UN Conference on Sustainable Development (Rio + 20) in 2012. Finally, in September 2015, the UN General Assembly (UNGA) adopted the 'Transforming our world: the 2030 Agenda for Sustainable Development' document.

The Agenda and its 17 Sustainable Development Goals (SDGs) have given a new impetus to global efforts for achieving sustainable development. The EU and its member states are committed to this historic global framework agreement and to playing an active role in maximizing progress towards the SDGs [2]. In particular, the balance between social cohesion and economic progress should feature more prominently in the EU actions in the global context. It is recognized that GDP alone does not provide a comprehensive picture of people's wellbeing; however, further collaborative efforts to develop a common approach to measuring the different dimensions of the Economy of Wellbeing are required [3]. The analysis of sustainability could be hampered by continuing to use economic growth as a goal in EU policy. At the same time, the United Nations Development Programme (UNDP) points out that countries that manage to make social progress in areas such as equity and social mobility also experience productivity gains because they can allocate resources more efficiently and have greater social acceptance and higher growth in the long run [4]. Indeed, there may be a significant risk of maintaining unsustainable practices in global markets, such as outsourcing and delocalization of environmental and social impacts [5].

The link between the social and economic spheres is reconfirmed in the study conducted by Ionescu et al. [6]. They analyzed the dynamics and structure for the 2025–2030 horizon of those goals that are "people-centered" and that pursue health, education, nutrition, and the wellbeing of people, at the level of EU member states. The basic idea is that different SDGs interact with each other in positive and negative ways and managing these interactions can lead to gains or losses [6,7].

Spaiser et al. [8] analyzed the presence of potential incompatibilities between SDGs. Specifically, they focused on the one existing between the SDGs linked to socio-economic development and those linked to environmental sustainability, as in recent years there has been an intrinsic conflict between the two approaches. Their results quantified this inconsistency, showing that economic growth meets socio-economic goals whilst hindering environmental ones.

In the unprecedented global context caused by the pandemic, an assessment of progress towards the SDGs agenda is even more important, as for many countries the achievement of targets by 2030 has become out of reach [9]. Nations have been and continue to be hardly hit, particularly in the health sector, but also in the education and employment fields [10]. The equality topic has also been greatly affected, and certainly the environmental and service areas too. All these problems turned into an economic crisis of which we do not know how it will evolve.

As mentioned above, sustainable development is fundamentally important, but it is also a complex concept. Nowadays, an increasing number of indicators are designed to measure the achievement of objectives, explore strengths and weaknesses and detail the structure of development [11]. Due to this complexity, the interpretation of the phenomena is challenging and requires a large set of separate indicators. The use of composite indicators (CI) in this context can be considered very useful, since they are easier to interpret, instead of trying to find a common trend in many separate indicators. CI have proven to be useful in ranking countries in benchmarking exercises; indeed, they are increasingly recognized as a valuable tool for policy making and public communications in conveying information on countries' performance in fields such as environment, economy, society, or technological development [12]. Composite indicators must be seen as a means of initiating discussion and stimulating public interest. However, their relevance should be evaluated with respect to constituencies affected by the composite index, in order to not draw simplistic analytical or policy conclusions of the users [13].

The composite index method was used by Balode et al. [14] to develop a methodology to pre-assess the impacts of policies identified in the NECP, a long-term energy and climate policy planning document that sets out the basic principles, measures and directions of Latvia's state energy and climate policy for the next ten years. In the study of Hübelová et al. [15], a composite indicator (health index) was developed to present a quantitative assessment of inequalities in health conditions between districts in the

Czech Republic. This index is composed of eight areas of evaluation: economic conditions and social protection, education, demographic indicators, environmental conditions, individual living conditions, road safety and crime, health and social care resources, and health status; a total of 60 indicators have been identified. The index is derived from the application of two multi criteria assessment methods: the TOPSIS (technique for order preference by similarity to ideal design) method and the weighted sum approach (WSA).

Predicting the future is always a difficult challenge, as Moyer and Hedden [16] point out, but models should be used to better understand what is occurring in the world around us depending on the path taken; starting from this understanding, policy could be developed considering the past, the present and possible future trajectories of sustainable human development. On this basis, the purpose of this study is to measure the relative degree of progress achieved by EU countries in human development and to highlight any disparities between countries, by means of a composite indicator, i.e., the Sustainability Development Goals Achievement Index (SDG-AI), covering six dimensions of the sustainable development and aggregating 32 indicators. Using this composite indicator, we were able to compare countries, assessing which ones have better conditions and which have lower values in terms of sustainability, considering the progress of the other countries. Through reading the outcomes, measures could be put in place to solve problems that hinder the achievement of some objectives and to try to improve the strengths of other objectives even more. The index also allows determination of which dimensions perform the best and vice versa, giving solid base to decision makers for action or correction through appropriate programmes. The analysis of the six dimensions and of the SDG-AI has been carried out using a spatial approach, thanks to the Spatial Sustainability Assessment Model (SSAM). In addition, the research also aims to analyze the coherence between the social development and economic growth of the EU member states.

2. Materials and Methods

2.1. SDGs Achievement Index

The aim of this study is to propose a tool, the SDGs achievement index (SDG-AI), for the assessment of the progress towards the targets of the 2030 agenda. The SDG-AI is based on the scheme proposed by Dhaoui [11], but modified in order to make it suitable for the EU context. In his work, Dhaoui proposed the SDG achievement index for the assessment of inclusive growth in MENA Countries (Middle East/North Africa). In particular, the paper contributes to the dialogue about the relation between inequality and growth. The original index consists of six core dimensions (Health, Education, Employment, Service, Equality, Environment): each one is divided into a variable number of sub-dimensions, described by a set of indicators. Indicators are aggregated in the sub-dimensions, and then in a global dimension, using linear aggregation (WSA) and weights based on the PCA approach.

The framework proposed by Dhaoui [11] is suitable for the circumstance of the MENA countries, in particular considering the indicators, whilst the core dimensions can also fit in different contexts. In order to specifically assess the results of the European countries, the present work proposes some modification in the general framework of the index, changing the indicators and eliminating the subdimensions. Moreover, the aggregation algorithm has also been changed using the TOPSIS method [17] for aggregating criteria.

2.1.1. Criteria Selection and Framework Construction

In order to modify the SDG-AI and make it suitable for the EU context, since the six dimensions can be considered as fixed, a selection of new indicators was conducted, considering in particular the principle of the relevance. Relevance comprises three different aspects [18]:

1. Link to the target: the indicator should be clearly linked to one or more targets and provide robust measures of progress towards the target(s).
2. Policy relevance: the indicator should be relevant to policy formulation and provide enough information for policy makers in the policy context selected (i.e., European Union).
3. Applicability at the appropriate level: the indicator should be relevant to national priorities and therefore measured.

The selection of the criteria in this work respected the three rules mentioned above. The criteria chosen are all part of the global indicators framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development. Such a framework was developed by the Inter-Agency and Expert Group on SDGs Indicators (IAEG-SDGs) and adopted for the first time by the General Assembly on 6 July 2017, as an instrument to measure the state of the art and progress of each SDG. Moreover, each indicator refers not only to a specific SDG, but also to a specific target; targets are different between developed and developing countries and can be very specific (i.e., 1.1: By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than USD 1.25 a day) or more general (i.e., 2.4: By 2030, ensure sustainable food production systems and implement resilient agricultural practices). The framework is annually revised in order to keep it updated. Last version available: https://unstats.un.org/sdgs/indicators/Global%20Indicator%20Framework%20after%202020%20review_Eng.pdf (accessed on 29 October 2021).

This framework can be complemented by another, including indicators at the regional and national levels, which are developed by the single member states. Therefore, the Statistical Office of the European Union, i.e., Eurostat, selected relevant indicators according to the EU perspective. Moreover, the elements of the 2030 Agenda that are less relevant for the EU as they focus on other parts of the world, (e.g., indicators where the targets specifically refer to developing countries) were not considered by Eurostat for monitoring the progress towards SDGs of the European Union [3]. Therefore, the policy relevance rule was also satisfied.

In this context, the selection of our criteria was based on the group used by Eurostat for measuring the EU members' progress towards the 2030 Agenda. Based on data availability, coverage of the various countries, and the quality of the data, Eurostat identified a set of 102 indicators along the 17 SDGs. Each goal has six indicators primarily attributed to it. Of the 102 indicators, 37 are multipurpose, i.e., are used to monitor more than one SDG. Figure 1 reports the SDGs considered in the current study, for each of the six dimensions of human development, in order to select the criteria, in the context of the Eurostat selection. Then, for each dimension, we chose the indicators that respected the representativeness and policy relevance for EU countries [18] and that were available at the national level for all the EU countries, avoiding redundancy and overlapping. The different targets that the EU countries have to reach are covered and measured by multiple overlapping and redundant indicators, in order to improve the description of the phenomenon. Therefore, we included as criteria for the analysis only the main indicators for each of the different targets, since overlap and redundancy have to be avoided in Multi- Criteria Decision Analysis (MCDA).

A total of 32 criteria have been identified, able to measure the level reached by the different EU countries for each dimension. Tables 1–6 show the division of the set of indicators into each of the six dimensions, reporting along with the name of the indicator also the code of it in the Global indicator framework for the Sustainable Development Goals. Overall, the criteria selected belong to 15 out of the 17 SDGs in the agenda. A brief description and the unit of measure of the indicators are also reported, and also whether they are gain (to be maximined) or cost (to be minimized).

HEALTH
SDG 3 - Good health and well-being
EDUCATION
SDG 4 - Quality Education
SDG 8 - Decent work and economic growth
SERVICE
SDG 6 - Clean water and sanitation
SDG 7 - Affordable and clean energy
SDG 9 - Industry, innovation and infrastructure
SDG 11 - Sustainable cities and communities
SDG 13 - Climate action
EMPLOYMENT
SDG 8 - Decent work and economic growth
EQUALITY
SDG 1 - No poverty
SDG 5 - Gender equality
SDG 10 - Reduced inequalities
ENVIRONMENT
SDG 13 - Climate action
SDG 15 - Life on land

Figure 1. Link between Sustainable Development Goals (SDGs) and dimensions for criteria selection.

Table 1. Health dimension.

Indicators	Description	Unit of Measure	Gain/Cost
Exposure to air pollution by particulate matter *(sdg_11_50)*	The indicator measures the population-weighted annual mean concentration of particulate matter at urban background stations in agglomerations.	particulates < 2.5 μm ($\mu g/m^3$)	C
Population living in households considering that they suffer from noise, by poverty status *(sdg_11_20)*	The indicator measures the proportion of the population who declare that they are affected either by noise from neighbors or from the street.	% of population	C
Self-reported unmet need for medical examination and care by sex *(sdg_03_60)*	The indicator measures the share of the population aged 16 and over reporting unmet needs for medical care due to one of the following reasons: 'Financial reasons', 'Waiting list' and 'Too far to travel'.	% of population aged 16 and over	C
Healthy life years at birth by sex *(sdg_03_11)*	The indicator of healthy life years (HLY) measures the number of remaining years that a person of specific age is expected to live without any severe or moderate health problems.	Years	G
Smoking prevalence by sex *(sdg_03_30)*	The indicator measures the share of the population aged 15 years and over who report that they currently smoke boxed cigarettes, cigars, cigarillos or a pipe.	% of population aged 15 and over	C
Obesity rate by body mass index (BMI) *(sdg_02_10)*	The indicator measures the share of obese people based on their body mass index (BMI). BMI is defined as the weight in kilos divided by the square of the height in meters.	% of population aged 18 or over; by BMI	C

Table 2. Education dimension.

Indicators	Description	Unit of Measure	Gain/Cost
Participation in early childhood education by sex (children aged 3 and over) *(sdg_04_31)*	The indicator measures the share of the children between the age of three and the starting age of compulsory primary education who participated in early childhood education.	% of the population	G
Early leavers from education and training by sex *(sdg_04_10)*	The indicator measures the share of the population aged 18 to 24 with, at most, lower secondary education, who were not involved in any education or training during the four weeks preceding the survey.	% of the population	C
Young people neither in employment nor in education and training by sex (NEET) *(sdg_08_20)*	The indicator measures the share of the population aged 15 to 29 who are not employed and not involved in education or training.	% of the population	C
Tertiary educational attainment by sex *(sdg_04_20)*	The indicator measures the share of the population aged 25–34 who have successfully completed tertiary studies (e.g., at university or a higher technical institution).	% of the population	G

Table 3. Service dimension.

Indicators	Description	Unit of Measure	Gain/Cost
Population unable to keep home adequately warm by poverty status *(sdg_07_60)*	The indicator measures the share of population who are unable to keep home adequately warm.	% of population	C
Greenhouse gas (GHG) emissions intensity of energy consumption *(sdg_13_20)*	The indicator is calculated as the ratio between energy-related GHG emissions and gross inland consumption of energy.	index 2000 = 100	C
Water exploitation index, plus (WEI+) *(sdg_06_60)*	The water exploitation index plus (WEI+) is a measure of total fresh water use as a percentage of the renewable fresh water resources (groundwater and surface water) at a given time and place.	% of long-term average available water (LTAA)	C
Population having neither a bath, nor a shower, nor indoor flushing toilet in their household by poverty status *(sdg_06_10)*	The indicator measures the share of total population having neither a bath, nor a shower, nor an indoor flushing toilet in their household.	% of population	C
Recycling rate of municipal waste *(sdg_11_60)*	The indicator measures the tonnage recycled from municipal waste divided by the total municipal waste arising.	% of total waste generated	G
High-speed internet coverage, by type of area *(sdg_17_60)*	The indicator measures the share of households with fixed very high capacity network (VHCN) connection.	% of households	G

Table 4. Employment dimension.

Indicators	Description	Unit of Measure	Gain/Cost
Employment rate by sex *(sdg_08_30)*	The indicator measures the share of the population aged 20 to 64 which is employed. Employed persons are defined as persons who, during a reference week, worked at least one hour for pay or profit or were not working but had jobs from which they were temporarily absent.	% of population	G
In work at risk of poverty rate *(sdg_01_41)*	The share of persons who are employed and have an equivalized disposable income below the risk of poverty threshold, which is set at 60% of the national median equivalized disposable income (after social transfers).	% of employed persons aged 18 or over	C
People killed in accidents at work, by sex *(sdg_08_60)*	The indicator measures the number of fatal accidents that occur during the course of work and lead to the death of the victim within one year of the accident. The incidence rate refers to the number of fatal accidents per 100,000 persons in employment.	Number per 100,000 employees	C
Inactive population due to caring responsibilities by sex *(sdg_05_40)*	The economically inactive population comprises individuals that are not working, not actively seeking work and not available to work. Therefore, they are neither employed nor unemployed and considered to be outside the labor force.	% of inactive population aged 20 to 64	C

Table 5. Equality dimension.

Indicators	Description	Unit of Measure	Gain/Cost
People at risk of poverty or social exclusion *(sdg_01_10)*	This indicator corresponds to the sum of persons who are at risk of poverty after social transfers, severely materially deprived, or living in households with very low work intensity.	% of population	C
Asylum applications by state of procedure *(sdg_10_60)*	The indicator shows the relation between the number of positive first instance decisions per million inhabitants and the number of first-time asylum applicants per million inhabitants. Shows the percentage of accepted asylum applications in relation to total applications.	% of accepted asylum applications	G
Gender pay gap in unadjusted form *(sdg_05_20)*	The indicator measures the difference between average gross hourly earnings of male paid employees and of female paid employees as a percentage of average gross hourly earnings of male paid employees.	% of average gross hourly earnings of men	C
Gender employment gap *(sdg_05_30)*	The indicator measures the difference between the employment rates of men and women aged 20 to 64. The employment rate is calculated by dividing the number of persons aged 20 to 64 in employment by the total population of the same age group.	Percentage points	C
Positions held by women in senior management positions *(sdg_05_60)*	The indicator measures the share of female board members in the largest publicly listed companies. Publicly listed means that the shares of the company are traded on the stock exchange.	% of positions	G
Income distribution *(sdg_10_41)*	The indicator is a measure of the inequality of income distribution. It is calculated as the ratio of total income received by the 20% of the population with the highest income (the top quintile) to that received by the 20% of the population with the lowest income (the bottom quintile).	Income quintile share ratio	C

Table 6. Environment dimension.

Indicators	Description	Unit of Measure	Gain/Cost
Greenhouse gas emissions by source sector *(sdg_13_10)*	The indicator measures total national emissions (from both Emission Trading Scheme and the Effort Sharing Decisions sectors) including international aviation of the so-called 'Kyoto basket' of greenhouse gases.	Index 1990 = 100 and tonnes of CO_2 equivalent per capita	C
Average CO_2 emissions per km from new passenger cars *(sdg_12_30)*	The indicator is defined as the average carbon dioxide (CO_2) emissions per km by new passenger cars in a given year. The reported emissions are based on type-approval and can deviate from the actual CO_2 emissions of new cars.	g CO_2 per km	C
Share of renewable energy in gross final energy consumption by sector *(sdg_07_40)*	The indicator measures the share of renewable energy consumption in gross final energy consumption according to the Renewable Energy Directive. The gross final energy consumption is the energy used by end-consumers (final energy consumption) plus grid losses and self-consumption of power plants.	% by sectors	G
Share of forest area *(sdg_15_10)*	The indicator measures the proportion of forest ecosystems in comparison to the total land area.	% of total land area	G
Surface of terrestrial sites designated under Natura 2000 *(sdg_15_20)*	The indicator measures the surface of terrestrial sites designated under Natura 2000.	terrestrial protected area (%)	G
Soil sealing index *(sdg_15_41)*	The indicator estimates the increase in sealed soil surfaces with impervious materials due to urban development and construction (such as buildings, constructions and laying of completely or partially impermeable artificial material, such as asphalt, metal, glass, plastic or concrete).	% of total surface	C

2.1.2. Aggregation Procedure

The choice of the most suitable MCDA for a specific problem can be considered as a multicriteria problem itself [19]. Therefore, it is not surprising that such an argument has received growing attention recently in the literature [19–21]. As Cinelli et al. [19] highlighted, the complexities start with the definition of the framework for the decision, and end with the method selection.

The SDG-AI is built using TOPSIS method [17] for aggregating criteria into the single dimension, and weighted summation for aggregation of the dimensions into the final index. TOPSIS is a utility-based compromising model, one of the most widely used MCDA approaches in the case of cardinal-scale criteria [22]. It is based on the concept that a group of alternatives can be ranked accordingly by their distance from both the positive ideal solution (best score in each criterion) and the negative ideal one (worst score in each criterion), measured using Euclidean distance. The distance measure in TOPSIS is used as a proxy for human preference. Alternatives can be ranked on the basis of the values assumed by the criteria, which are considered as monotonically increasing or decreasing and therefore to be maximized or minimized [22]. The choice of TOPSIS in this application deals with the type of criteria used (cardinal) [22] and its good performance in case of a larger number of alternatives [22]; moreover, it was chosen because its logic is rational and understandable, and also the computation processes are straightforward [23].

The TOPSIS procedure consists of the following steps:

STEP 1: Establish a performance matrix

Let $U = \{u_1, u_2, u_3, \ldots, u_n\}$ be a finite set of criteria (n = 32 in the case study) and $A = \{A_1, A_2, A_3, \ldots, A_m\}$ a discrete set of feasible alternatives (m = 26 in the case study),

representing the EU countries. Each alternative A is evaluated with respect to the n criteria, whose values constitute a decision matrix denoted by:

$$Z = (z_{ij})_{mxn} = \begin{matrix} \\ A_1 \\ \vdots \\ A_n \end{matrix} \begin{matrix} \begin{matrix} u_1 & \dots & u_n \end{matrix} \\ \begin{pmatrix} z_{1,1} & \dots & z_{1,n} \\ \vdots & \ddots & \vdots \\ z_{m,1} & \dots & z_{m,n} \end{pmatrix} \end{matrix} \quad (1)$$

The z_{ij} represents the performance value of the j-th EU countries with respect to the i-th criterion described in Section 2.1.1.

STEP 2. Normalize the decision matrix

In the classical TOPSIS approach, the normalized performance matrix can be obtained using the following transformation formula [18]:

$$a_{ij} = \frac{z_{ij}}{\sqrt{\sum_{j=1}^{m} (z_{ij})^2}}, \quad j = 1, \dots, m, \quad i = 1, \dots, n \quad (2)$$

where a_{ij} is the normalized value of the performance value of the j-th EU countries with respect to the i-th criterion.

Consequently, after normalization, each attribute has the same unit scale.

STEP 3. Calculate the weighted normalized decision matrix

Weights in TOPSIS can be determined in two different ways: user-defined subjective weighting methods and entropy-based objective weighting procedures [24]. In complex scenarios, the first group of methods can be too difficult to apply and may lead to unsatisfactory results: the decision-maker(s) may be unable or unwilling to provide cohesive and exact numerical judgments regarding the relative importance or weights of criteria [24]. In these cases, which is also the context of the present analysis, an entropy-based object weighting scheme can be applied. The weights for the set of criteria are quantified using Shannon's entropy theory [25] of information theory. Information entropy is a measure of the degree of disorder within a system. It can quantify the amount of expected and useful information content within criterion values, and it measures the contrast intensity among a set of criteria within a decision matrix [25]. Based on Shannon's entropy concept, the entropy index, E_i, for the i-th criterion can be calculated as follows:

$$E_i = \begin{cases} -\frac{\sum_{i=1}^{n} a_{ij} \ln(a_{ij})}{\ln(m)}, & a_{ij} \neq 0 \\ 0, & a_{ij} = 0 \end{cases} \quad (3)$$

E_i is always in the interval 0–1. The value $1 - E_i$ describes the degree of diversity for the i-th criterion. Using the degree of diversity, entropy-based weights for each criterion (w_i), can be calculated as:

$$w_i = \frac{1 - E_i}{\sum_{i=1}^{n} (1 - E_i)} \quad (4)$$

Then the weighted normalized value (v_{ij}) can be calculated as:

$$v_{ij} = w_j \otimes a_{ij}, \quad j = 1, \dots, m, \quad i = 1, \dots, n \quad (5)$$

STEP 4. Determine the positive ideal and negative ideal solutions

The positive ideal value set (A^+) and the negative ideal value set (A^-) are determined as follows:

$$A^+ = \{v_1^+, \dots, v_n^+\} \{(\max v_{ij},\ i \in I)(\min v_{ij},\ i \in I')\} \quad (6)$$

$$i = 1, 2, \dots, 32$$

$$A^- = \left\{v_1^-, \ldots, v_n^-\right\}\left\{\left(\min v_{ij},\ i \in I\right)\left(\max v_{ij},\ i \in I'\right)\right\} \quad (7)$$
$$i = 1, 2, \ldots, 32$$

where I is associated with benefit criteria, and I' is associated with cost criteria.

STEP 5. Calculate the separation measures

The separation of each alternative (i.e., EU country) from the positive ideal solution A^+ is given as follows:

$$d_i^+ = \sqrt{\left\{\sum_{j=1}^{m}\left(v_{ij} - v_j^+\right)^2\right\}}, i = 1, \ldots, n \quad (8)$$

and the separation of each alternative from the negative ideal solution A^- is as follows:

$$d_i^- = \sqrt{\left\{\sum_{j=1}^{m}\left(v_{ij} - v_j^-\right)^2\right\}}, i = 1, \ldots, n \quad (9)$$

TOPSIS can be applied using different type of distances; we used the Euclidean distance.

STEP 6. Calculate the relative closeness to the ideal solution

The relative closeness R_j to the ideal solution can be expressed as follows:

$$R_j = \frac{d_i^-}{d_i^+ + d_i^-},\ i = 1, \ldots, n \quad (10)$$

$$\text{If } \overline{R_j} = 1 \rightarrow A_i = \overline{A^+} \text{ If } \overline{R_j} = 0 \rightarrow A_i = \overline{A^-}$$

where the $\overline{R_j} = 1$ value lies between 0 and 1. The closer the value is to 1, the higher the priority of the j-th alternative.

STEP 7. Rank the preference order

Rank the best alternatives according to R_j in descending order, which mean to rank the EU countries for each of the six dimensions.

The procedure of aggregation for having the global index, SDG-AI, has been realized using weighted summation as follows:

$$SDG - AI = \sum_{k=1}^{6} w_k D_{kj} \quad (11)$$

where w_k represents the weight of the k-th dimension and D_{kj} the index of the k-th index for the j-th country.

2.1.3. Spatial Sustainability Assessment Model (SSAM)

All the assessments have been done using the Spatial Sustainability Assessment Model (SSAM), a plugin developed within QGIS, which is a free and open-source Geographic Information System (GIS) software, widely used in several fields and applications. The model is an evolution of a previous plugin, GeoUmbriaSUIT [26], specifically developed for completely integrated spatial multicriteria analysis: it means that MCDA and GIS use the same interface and the same database. The MCDA model is activated inside the GIS software. The interface provides for a set of subsequent screens, in which the user is guided in inserting data initially, and then in performing the multicriteria analysis. By default, SSAM proposed the assessment of three indexes, based on the three pillars of sustainability (EnvIdeal, SocIdeal and EcoIdeal). The different criteria in each dimension are aggregated applying TOPSIS, whilst the different dimensions are then aggregated using

weighted summation. In comparison to GeoUmbriaSUIT, SSAM allows more flexibility in the application thanks to the possibility to add customed dimensions in addition or in replacement of the three pillars of sustainability.

Moreover, from a technical point of view, both GeoUmbriaSUIT and SSAM use geographic vector file, but with different formats (e.g., shapefile vs. geopackage). In the geographic vector file, the graphic data represent the study area and the single evaluation units within it to be compared, i.e., the alternatives (e.g., the European countries), whilst the alphanumeric data (attribute table) describes the aspects related to the evaluation units by means of a set of indicators (criteria). In relation to the data requested for the functioning of the model, a limited input is required from the user (such as data associated to indicators, with the weights needed for the weighting process). More details about the SSAM and its output can be found in Boggia et al. [26] and in the user manual of the plugin http://maplab.alwaysdata.net/doc/html/index.html (accessed on 15 October 2021).

In this paper, we used SSAM to aggregate the 32 criteria into six indices, one for each dimension, and then to compute the global rank, producing the SDGs Achievement Index.

2.2. Data and Assumptions

In order to measure the global development level of the 27 European Union Countries, considering the SDGs Achievement Index, data have been selected from the Eurostat website, referring to the indicator set of the 17 Sustainable Development Goals (SDGs). The complete performance matrix is reported in the Appendix A. The year chosen is 2019, in order to have a pre-COVID picture and to see how the global pandemic will hit the level of achievement in the next 5–10 years.

For some specific countries or a given indicator, adjustments have been required because of some missing data. Therefore, it was necessary to make a simplification in order to impute the missing values.

Following the work of Benedek et al. [9], as a common rule, in the case of missing data for the selected reference year (2019), the data has been replaced with the previous year value (2018). If the previous year was also missing, we went back to find the most recent data available. More specifically:

1. Indicator 6_6: missing data for all the countries; all data have been replaced with 2017 values, except for Estonia (first available year 2015);
2. Indicator 11_6: Bulgaria and Ireland data has been replaced with 2018 values;
3. Indicator 8_6: Belgium and Finland data has been replaced with 2018 values;
4. Indicator 5_2: Ireland and Greece data has been replaced with 2018 values;
5. Indicator 15_1: missing data for all the countries, data have been replaced with 2018 values;
6. Indicator 11_5: Malta has no data available at all. Therefore, the median value has been used as a proxy and ascribed to Malta.

3. Results and Discussion

3.1. The Overall SDGs Achievement Index

The SDGs Achievement Index (SDG-AI) was calculated, by the means of weighted sum. SDG-AI gives us a picture of the global situation, without specifying which dimensions are the best and worst for each state; Figure 2, which is one of the main outputs of SSAM, gives a quick and easy understanding of the geographic distribution of the index. The alternatives are grouped in a five classes scale, from very low to very high values of the index, and the definition of the range for each class is based on a QGIS function, i.e., the equal interval algorithm.

Denmark, Finland and Sweden obtained very high final values (between 67.86 and 76.24) and they resulted in Class 5, the best one. In Class 4, with a high level and a value of 64.34, only the Netherlands was found. Within the medium group (Class 3), there were the following states: Austria, Belgium, Estonia, France, Germany, Latvia, Luxembourg, Portugal, Slovenia and Spain. Ireland, Italy, Lithuania, Malta, Poland, Czech Republic,

Slovakia had a value between 42.66 and 51.05 and therefore resulted in the fourth class, while Bulgaria, Cyprus, Croatia, Greece, Romania and Hungary are in the worst one.

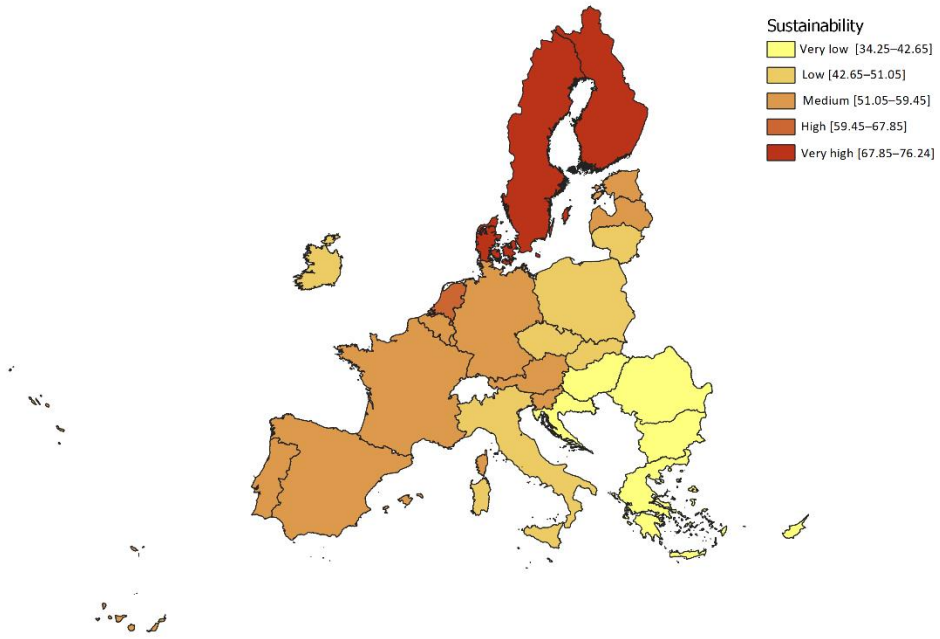


Figure 2. Map of the spatial distribution of the SDGs Achievement Index among EU Nations.

3.1.1. Back Analysis

In order to better understand these results, the Spatial Sustainability Assessment Model has a very important tool, i.e., the back analysis. Thanks to the application of the Dominance-based Rough Sets Approach (DRSA) [27], it allows the user to analyze each single step that leads to the final result, revealing which indicators have the greatest impact on the results [26].

DRSA is not used to get a ranking but rather to extract the decision rules that can explain the positions obtained by the alternatives in the ranking, based on the criteria used. Using it, transparency, traceability and back analysis capability are increased. Traceability means that from the final score it is possible to go back to the rules, and from the rules back to the input data [26].

In this case, the indicators responsible for the very low values of the countries belonging to the fifth group can be identified. Table 7 reports the results of such analysis, in the first column, and then the 2nd to 5th columns explain the meaning of the rule in terms of involved indicators, threshold value and class, plus the countries for which the rule is true.

In particular, Greece and Bulgaria have the highest values in the indicator "People at risk of poverty or social exclusion" in the Equality dimension, together with Romania, and in the indicator "Smoking prevalence by sex" in the Health sphere, together with Croatia. These two bad results determine the classification in the very low class.

Cyprus has the worst value in the Employment dimension for the indicator "Inactive population due to caring responsibilities by sex", with a population outside the labor force of 42.9%. In contrast to Cyprus, Denmark achieves the best result for this indicator, with a very low percentage (4.9%). It is precisely for this reason that it is in the first group, where states reach very high levels of sustainability. In this class we also find Sweden and Finland, which have very good values in the Environment dimension for the indicator "Share of forest area", being is 67% for the former and 69.9% for the latter.

Table 7. Back analysis. First column reports the rule as it comes out from Spatial Sustainability Assessment Model (SSAM), whilst columns 2 and 3 report the indicator and the value that are in the rule. Finally, column 4 indicates the classification derived from the rule, and column 5 indicates the countries for which the rule is true.

Rule	Indicator	Value	Class	Countries
IF [(EQ_Social_ex ≥ 30.0)] THEN AT MOST CLASS "very low"	People at risk of poverty or social exclusion	≥30	Very low	Greece, Romania, Bulgaria
IF [(EM_Inactive ≥ 42.9)] THEN AT MOST CLASS "very low"	Inactive population due to caring responsibilities	≥4 2.9	Very low	Cyprus
IF [(EM_Inactive ≤ 4.9)] THEN AT LEAST CLASS "very high"	Inactive population due to caring responsibilities	≤16	Very high	Denmark
IF [(H_Smoke ≥ 36.00000000)] THEN AT MOST CLASS "very low"	Smoking prevalence	≥36	Very low	Bulgaria, Greece, Croatia
IF [(H_Smoke ≤ 16.00000000)] THEN AT LEAST CLASS "high"	Smoking prevalence	≤16	High	Denmark, Finland, Netherlands, Sweden
IF [(S_GHG_int ≥ 94.9)] THEN AT MOST CLASS "low"	Greenhouse gas emissions intensity of energy consumption	≥94.9	Low	Cyprus, Bulgaria, Lithuania
IF [(EM_Employment ≤ 66.7)] THEN AT MOST CLASS "low"	Employment rate	≤66.7	Low	Greece, Croatia, Italy
F [(EN_Soil_sealing_I ≤ 0.47)] THEN AT LEAST CLASS "medium"	Soil sealing index	≤0.47	Medium	Estonia, Finland, Latvia, Sweden
IF [(EM_Incident ≤ 0.79)] THEN AT LEAST CLASS "medium"	People killed in accidents at work	≤0.79	Medium	Germany, Netherlands, Sweden
IF [(EN_Forest ≥ 67.0)] THEN AT LEAST CLASS "very high"	Share of forest area	≤16	Very high	Sweden, Finland

3.1.2. Sensitivity Analysis

The TOPSIS method is a method largely used for four main reasons [28]:

- it is rational and understandable;
- the computation processes are straightforward;
- the concept permits the pursuit of the best alternatives for each criterion depicted in a simple mathematical form; and
- the importance weights are incorporated into the comparison procedures.

Despite these positive aspects, one of the main problems which may arise in the TOPSIS method is the presence of rank reversal, which is a phenomenon also present also in other multicriteria methods (i.e., the Analytic Hierarchy Process (AHP)). When rank reversal happens, the alternatives' order of preference changes by adding or removing alternatives from the decision problem; in the case of total rank reversal, the order of preferences can be completely inverted (i.e., the best, after the inclusion or removal of an alternative from the process, becomes the worst) [23]. This is a serious problem, as the rank reversal violates the invariance principle of utility theory [29].

In order to see if there is the risk of rank reversal for the current application of the SDG-AI, a sensitivity analysis has been performed using the approach suggested by Socorro García-Cascales [23]. Two fictitious alternatives which correspond with the best possible valuation and with the worst possible one have been introduced to see if this could cause any change in the final ranking.

Table 8 reports the outcomes of such analysis. The rank modification has been considered only for the EU nations and do not also include the two fictitious alternatives. Some

rank reversals happened: only nine countries maintained their position. In particular, the top three alternatives switched their position, and 4 out of 6 of the countries in Class 1 switched their position. Class 3 was the most stable, with the higher number of no change in comparison to the total number of alternatives.

Table 8. Rank reversal analysis; arrows indicate whether a nation changes rank to a worse (↓), better (↑), or stable class (↔).

Country Code	Original Rank	Original Class	New Rank		New Class	
SE	1	Very High	2	↓	Very High	↔
DK	2	Very High	3	↓	Very High	↔
FI	3	Very High	1	↑	Very High	↔
NL	4	High	5	↓	High	↔
AT	5	Medium	4	↑	High	↑
DE	6	Medium	6	↔	Medium	↔
PT	7	Medium	7	↔	Medium	↔
SI	8	Medium	10	↓	Medium	↔
LU	9	Medium	9	↔	Medium	↔
EE	10	Medium	8	↑	Medium	↔
FR	11	Medium	11	↔	Medium	↔
BE	12	Medium	14	↓	Medium	↔
LV	13	Medium	13	↔	Medium	↔
ES	14	Medium	12	↑	Medium	↔
MT	15	Low	15	↔	Low	↔
IE	16	Low	16	↔	Low	↔
LT	17	Low	19	↓	Low	↔
IT	18	Low	17	↑	Low	↔
CZ	19	Low	18	↑	Low	↔
PL	20	Low	21	↓	Very Low	↓
SK	21	Low	20	↑	Low	↔
HU	22	Very Low	23	↓	Very Low	↔
HR	23	Very Low	22	↑	Very Low	↔
RO	24	Very Low	24	↔	Very Low	↔
BG	25	Very Low	25	↔	Very Low	↔
CY	26	Very Low	27	↓	Very Low	↔
EL	27	Very Low	26	↑	Very Low	↔

The situation is less dramatic when considering if the new position also affects the belonging to a certain class. In this case, the EU nations in the superior and inferior classes remained unchanged; Class 2 increases by one unit, with Austria added to the Netherlands. Class 4 lost one nation to Class 5 (Poland). Therefore, we can say that at least the class grouping produced strong and stable results, which means that SDG-AI classes are a good basis for policy strategies.

3.2. From the SDG-AI to Dimension Indices

The SDG-AI is built on six indices—Health, Education, Service, Employment, Equality and Environment—and each of these dimensions contributes differently in the composition of the overall index.

This is illustrated in Figure 2, where the entire bar is a measure of the total ranking given by the combination of all spheres; the higher the bar, the higher the level of sustainable development achieved by each country. However, this graph does not represent the SDG-AI: it is just a representation of the different dimensions, stacked one on the other, without a weighting phase. Nonetheless, the graph allows identification of the contribution of each sphere to the final ranking. The bars of sustainability (Figure 3) is one of the graphical outputs produced by SSAM.

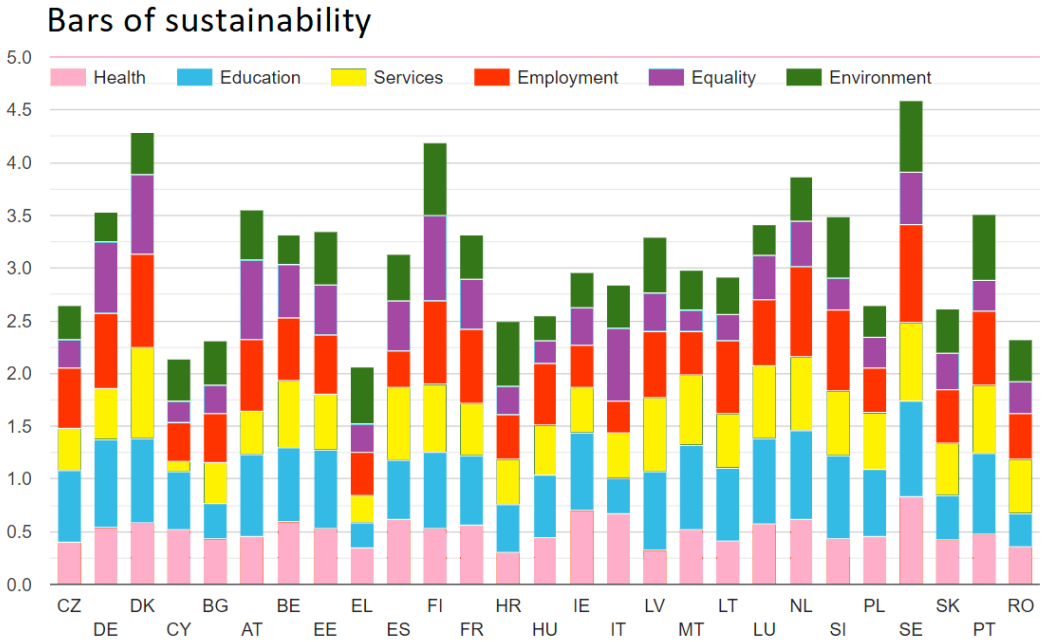


Figure 3. Bars of sustainability: the graph represents the different dimensions stacked one on the other, without weighting.

For instance, Figure 3 shows that Denmark's worst dimension is the environment, and considering the absolute value, this also has the lowest value compared to the other states. In terms of the overall index, however, the country is in the second position in Class 5, so this low value in the environmental dimension is certainly compensated by those of the other dimensions. On the contrary, Croatia and Greece, both at the bottom of the global ranking, have the best environmental performance (Figure 2), reaching the fourth and sixth positions, respectively. For some authors [30], SDGs fail to monitor absolute trends in resource use due to the lack of target. Therefore, the SDG-AI reflects the little importance of the ecological dimension within the targets and goals, as it is based on the Agenda framework. Moreover, due to the compensation, undervaluation of natural resources is further stressed.

Figure 4 reports another output directly produced by SSAM: the map of each dimension, in which the different nations are grouped in five classes, as for the global index. Sweden, Denmark and Finland, the nations ranked as the three best according to the SDG-AI, are often in the top group in the different dimension maps: 5 out of 6 dimensions for Sweden, 4 out of 6 for Denmark, and 2 out of 6 for Finland. Moreover, none of them rank in a class lower than high in all the other dimensions, with the only exception being the Environmental rank for Denmark. The presence of the worst performance in the Environmental dimension for the EU countries with better classification has already been highlighted, in particular for the Denmark case [31].

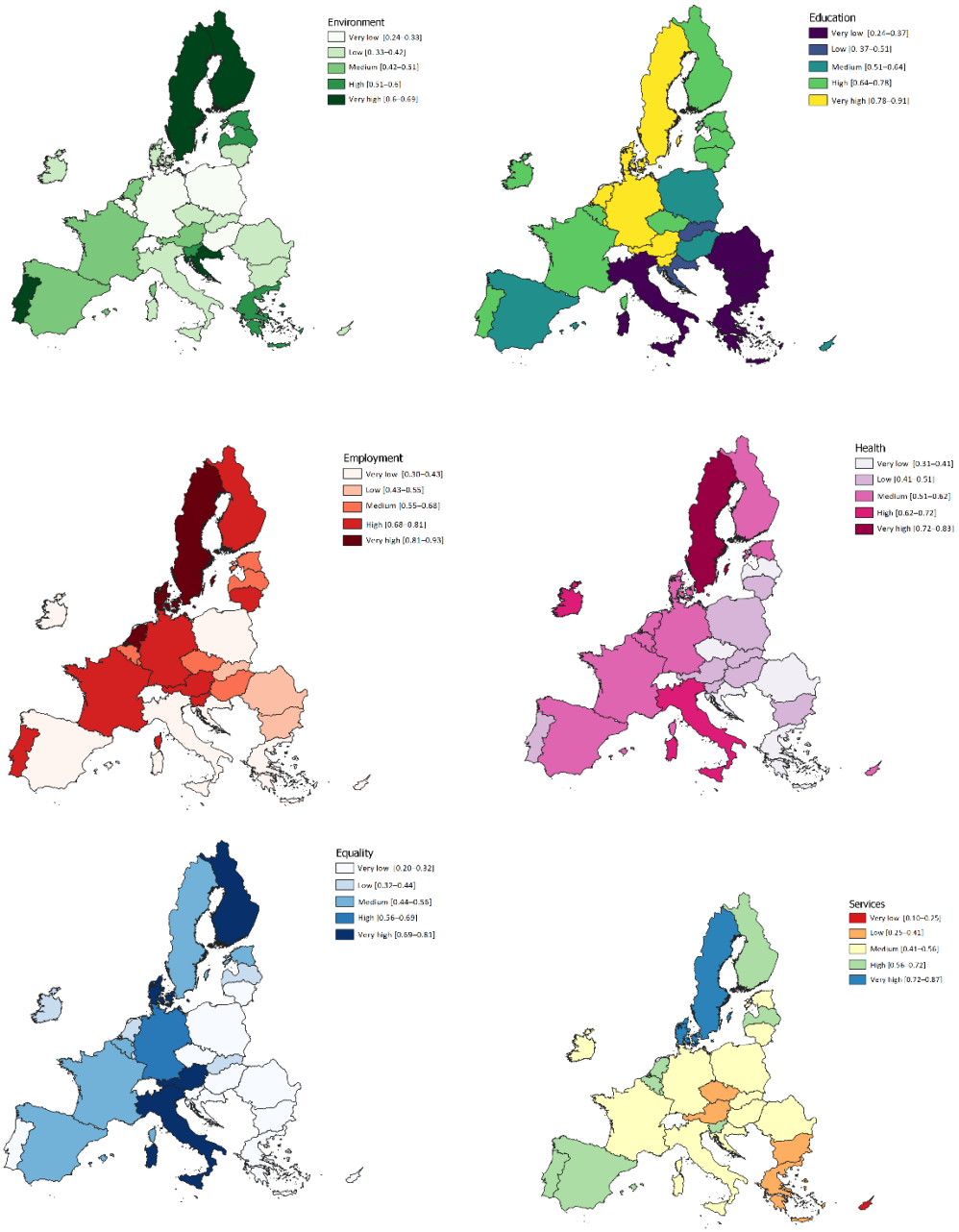


Figure 4. Maps of the six dimensions; left to right and top to bottom: Employment Index, Environment Index, Equality Index, Health Index, Education Index and Services Index.

On the contrary, the group of the worst EU members (Bulgaria, Cyprus, Croatia, Greece, Romania and Hungary) performs in a variable way in the different dimensions, in comparison to the SDG-AI. Bulgaria is always at least in the low class, as well as Romania, Cyprus (with the exception of the Education and Health indices) and Greece (with the exception of the Environmental index). Croatia is in the very low group for Health (worst absolute value in the distribution), Employment and Equality, but it is very good for Environment, good for Education, and median for Services. Hungary is in Class 3 for the Employment and Equality indices, but it is at least in the low class for all the others. All the regions classified as low for the SDG-AI are also in the worst class for the Equality dimension index. Therefore, it reasonable to state that, in such countries, the post-pandemic scenario will require a vast policy approach and investments in order to recover not only the effects of the pandemic but also the previous gap.

The distribution of the values within the dimension is reported by Figure 5, which indicates the maximum, minimum and median values for all the six indices. From the figure, it emerges that for Education, the median value is high, therefore there are several nations with good performance; indeed, 17 out of 27 countries are classified in the high and very high class for this dimension. On the contrary, for Equality and Environment, the median is low, which means that half of the countries perform in an unsatisfactory way. As matter of fact, 15 for Environment and 17 for Equality out of 27 nations are classified at most in the low class.

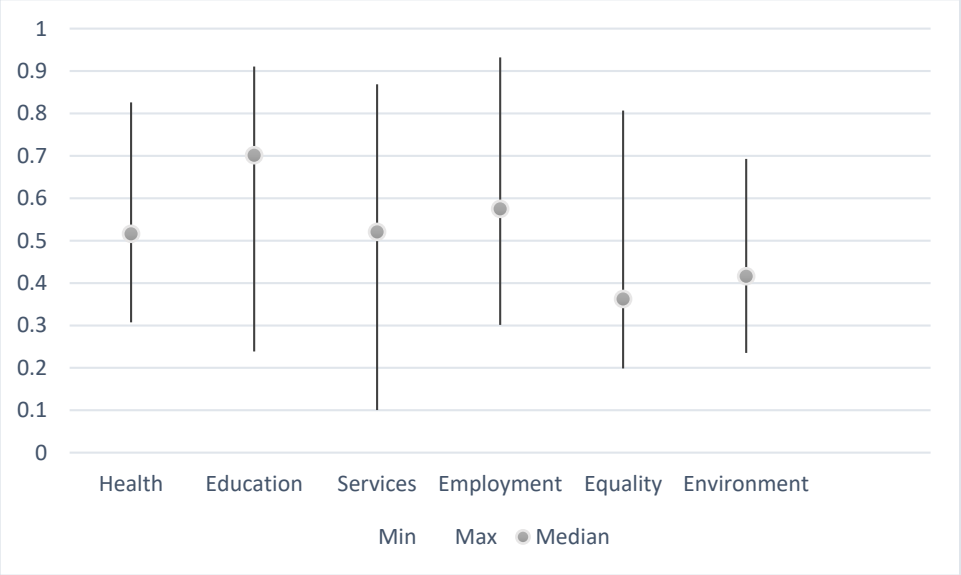


Figure 5. Maximum, minimum and median values for the singular dimensions.

3.3. Correlation between Composite Partial Indicators

Statistical independency of the six dimensions is not needed, whilst the absence or presence of it can be used to better understand both the results of the SDGs achievement index and specific phenomena [11]. These links help to understand the elaboration of the composite indicator. Moreover, the relationship across the different SDGs and their influencing areas has been well described by several authors, such as Nilsson et al. [32] and Fonseca et al. [33]. Although the mutual relationship among the 17 SDGs is not completely unveiled, some trade-off and synergies are recognized, such as the one between SDG1 (Poverty elimination) and SDG3 (Good health and well-being), or among SDG7 (Affordable and clean energy) and several other SDGs (e.g., SDG1 (No poverty), SDG2 (Zero hunger), SDG3 (Good health and well-being), SDG8 (Decent work and economic growth), and SDG13 (Climate action)) [33]. SDG11 and SDG12 are among the most interlinked with the others [33,34]. Studying the SDG interlinkages is crucial, since the presence of trade-off and synergies may condition the achievement of the Agenda goals themselves [35]. As Kostetckaia and Hametner highlighted for EU countries, there are both significant negative and positive relationships between countries' progress and interlinkage, with a bigger influence of tradeoff on the pace of countries' progress towards the goals than synergies [35].

Our work does not show strong interlinkage, considering the different indices. In general (Table 9), there are no strong correlations between the different indices. The highest correlation is found between the Education and Employment dimensions, which have a positive Pearson statistic of 0.703 and a significant level (p = 0.0001%). This result can be explained by the impact of the NEET phenomenon (Neither in Employment or Education or Training) and its relation to both the labor and educational world. Fair correlation values were also found for the dimensions of Services and Education (0.588, p = 0.001), Health and Education (0.433, p = 0.024), Health and Equality (0.457, p = 0.16), and Employment

and Equality (0.418, $p = 0.029$). All the correlations are positive, except for the one between Health and Environment; however, it is neither significant nor relevant.

Table 9. Correlation matrix.

	Health	Education	Services	Employment	Equality	Environment
Health	1.00000000	0.43313427	0.34122344	0.23500756	0.45761836	−0.03295767
Education	0.43313427	1.00000000	0.5884303	0.7025891	0.2917469	0.0357793
Services	0.34122344	0.5884303	1.00000000	0.5876771	0.3284906	0.1638924
Employment	0.23500756	0.7025891	0.5876771	1.00000000	0.4184404	0.3013158
Equality	0.45761836	0.2917469	0.3284906	0.4184404	1.00000000	0.1628260
Environment	−0.03295767	0.0357793	0.1638924	0.3013158	0.1628260	1.00000000

3.4. Growth and Development: SDG-AI and GDP

As performed by Dhaoui [11], we attempted to find a linkage between SDG-AI and Gross Domestic Product (GDP) per capita, for understanding: (1) if there is a link in EU countries between the level of sustainable development and growth; and (2) in the case of the presence of a link, to understand how strong it is. Indeed, the SDG-AI points out the achievement in terms of development for society, and it maybe could be expected that countries with a high index value have also a high GDP per capita.

The distribution of SDG-AI and GDP is shown in Figure 6. The regression analysis shows a loose relation between the two indices (R2 = 0.229), with several countries which divert from the supposed pathway. For instance, the nations with the higher GDP per capita (Luxemburg and Ireland) have medium performance for the SDG-AI. The countries in Class 5 for SDG-AI have good values for GDP; however, they are the countries more distant from the trend line. On the contrary, there are stronger connections between SDG-AI and GDP in the group with a low level of SDG-AI and GDP, although in the worst group (Class 1) the connection is weaker. It should be noted that the creation of the SDG-AI implies the use of both normalization and weights; therefore, the relation with GDP but also other measurements could be increased or decreased by them [11].

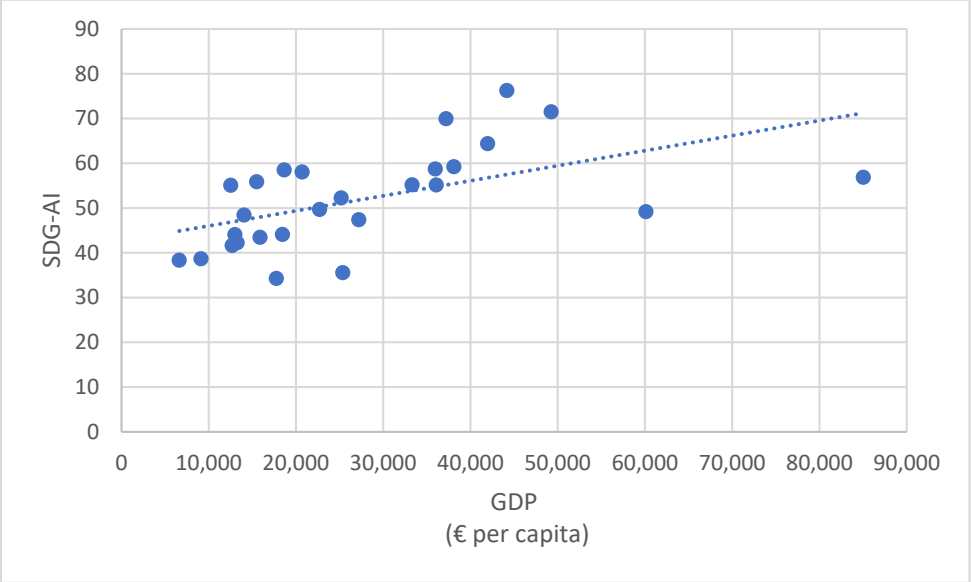


Figure 6. Link between the composite indicator SDG-AI (expressed in points) and Gross Domestic Product (GDP) per capita (expressed in euro per capita).

4. Conclusions

This paper proposed the evolution of an existing sustainability index in order to measure the progress of the EU countries towards the achievement of the objectives of Agenda 2030. To do that, we proposed an assessment framework, applied to EU countries but suitable for other countries at the global level as well. This framework included six dimensions (Health, Education, Services, Employment, Equality and Environment) based on 32 criteria. The six dimensions have been used to create a composite indicator, the Sustainable Development Goals Achievement Index (SDG-AI), able to represent all the sustainability information.

The reference year was 2019, in order to have a pre-pandemic assessment to be used in the future for understanding the possible changes in the pathway to Sustainable Development Goals achievement due to the pandemic. The composite indicator enabled us to rank the countries according to their performance, using a multicriteria spatial tool, SSAM.

The results showed that within the EU countries, Nordic ones are the most advanced in term of SDG-AI. In general, such countries are at the top of the ranking for all the dimensions, apart from the Environmental dimension for Denmark. The EU Baltic countries and the former Eastern bloc countries have the worst performance. It will be an urgent and important task in these countries to adopt a different approach to improve in particular the Equality dimension, which includes gender equality, immigrant inclusion and income distribution.

Connection across the different dimensions has been found, among Health, Education, Equality and Employment. On the contrary, a lacking connection between the economic growth, measured by pro capita GDP, and sustainable development, measured by SDG-AI, has been found.

Further development, both in the application and in the algorithm of the SDG-AI, will be possible in the near future. In particular, due to the current pandemic situation, the monitoring of the achievement progress towards the 2030 Agenda should be applied in order to understand how much COVID-19 will impact on the success of the Agenda itself. Increasing knowledge on this issue will help policy makers to modify, if necessary, the Sustainable Development Goals according to changes in the scenario and changes in priorities due to the health emergency caused by the pandemic.

From a methodological point of view, in the present version, the construction of the composite indicator is based on compensatory methods, which allows compensation of good and bad performances among the different criteria. According to the theory of sustainable development, this feature involves the application of a weak sustainability approach. Weak sustainability is not capable of effectively tackling serious environmental (e.g., climate crisis, biodiversity loss), social (e.g., gender disparity, migratory flows) and economic (e.g., hunger, poverty) problems. Therefore, we are working on the development of a non-compensatory method, which is able to apply a strong sustainability approach in the SDG-AI calculation.

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Appendix A. Performance Matrix

Table A1. Performance matrix of the EU countries.

	HEALTH						EDUCATION				SERVICE					
	11.5 Exposure to Air Pollution by Particulate Matter	**11.2 Population Living in Households Considering That They Suffer from Noise, By poverty Status**	**3.6 Self-Reported Unmet Need for Medical Examination and Care by Sex**	**3.11 Healthy Life Years at Birth by Sex**	**3.3 Smoking Prevalence by Sex**	**2.1 Obesity Rate by Body Mass Index (BMI)**	**4.31 Participation in Early Childhood Education by Sex (children Aged 3 and over)**	**4.1 Early Leavers from Education and Training by Sex**	**4.2 Tertiary Educational Attainment by Sex**	**8.2 Young People Neither in Employment Nor in Education and Training by Sex (NEET)**	**7.6 Population Unable to Keep Home Adequately Warm by Poverty Status**	**13.2 Greenhouse Gas Emissions Intensity of Energy Consumption**	**6.6 Water Exploitation Index, Plus (WEI+)**	**6.1 Population Having Neither a Bath, Nor a Shower, Nor Indoor Flushing Toilet in Their Household by Poverty Status**	**11.6 Recycling Rate of Municipal Waste**	**17.6 High-Speed Internet Coverage, by Type of Area**
Belgium	11.1	16	1.8	62.4	21	50.2	98.3	8.4	47.3	11.8	3.9	84.6	7.31	0.1	54.7	66.5
Bulgaria	19.6	8.9	1.4	66.3	38	54.9	79.9	13.9	32.7	16.7	30.1	97.1	1.78	7.5	31.5	42
Czechia	14.4	14	0.5	62	30	60	86.3	6.7	32.6	9.8	2.8	73.6	19.53	0.2	33.3	29.3
Denmark	10	20.1	1.8	58.9	16	50.4	97.7	9.9	47.1	9.6	2.8	63.1	1.49	0.3	51.5	93
Germany	10.9	26.1	0.3	66.3	23	53.5	94	10.3	33.3	7.6	2.5	87.2	5.46	0	66.7	32.7
Estonia	4.8	8.2	15.5	55.8	18	56.7	91.5	9.8	42.8	9.8	2.5	79.7	9.95	3.5	30.8	57.4
Ireland	8.8	8.2	2	69.6	18	54.4	100	5.1	55.4	11.4	4.9	79.6	2.98	0.1	37.6	35.4
Greece	14.1	19.7	8.1	66	42	57.6	68.8	4.1	42.4	17.7	17.9	74.9	39.37	0.2	21	7.1
Spain	11.8	14.1	0.2	69.9	24	53.7	97.3	17.3	46.5	14.9	7.5	79.7	23.71	0.3	34.7	89
France	10.4	17.3	1.2	64.1	28	47.2	100	8.2	48.2	13	6.2	79.5	6.14	0.2	46.3	43.8
Croatia	16	8.2	1.4	57.4	36	64.8	79.4	3	35.5	14.2	6.6	86.6	0.36	0.8	30.2	43.2
Italy	15.1	11.9	1.8	68.3	23	45.7	93.6	13.5	27.7	22.2	11.1	82.2	15.58	0.5	51.4	30
Cyprus	13.4	15.4	1	62.5	28	49.8	90.1	9.2	60.3	14.1	21	94.9	70.3	0.5	15	10.1
Latvia	12.1	13.1	4.3	53.1	32	58.3	94.1	8.7	43.8	10.3	8	83.8	0.22	7.7	41	88.1
Lithuania	11.1	13.3	1.4	57.5	28	56.8	89.6	4	55.2	10.9	26.7	102.6	0.38	8.7	49.7	61
Luxembourg	10.2	20.2	0.2	62.6	23	48.4	88.4	7.2	56.1	6.5	2.4	92.4	2.92	0.1	48.9	92
Hungary	14.4	9.7	1	61.7	28	59.9	92.9	11.8	30.6	13.2	5.4	77.3	1.19	2.7	35.9	42.6
Malta	11.9	28.3	0	73.2	20	64.8	91.9	13.9	40.8	7.9	7.8	58.7	18.54	0	8.9	100
Netherlands	10.4	26.6	0.2	61	12	50	90.5	7.5	49.1	5.7	3	92.6	4.15	0	56.9	88.6
Austria	12	19.5	0.3	57.3	25	52.2	89.9	7.8	41.6	8.3	1.8	83.9	1.78	0.1	58.2	13.8
Poland	19.3	12.6	4.2	62.5	26	58.1	90.3	5.2	43.5	12	4.2	85.9	6.87	1.6	34.1	60.3
Portugal	9.1	22.7	1.7	59.2	21	55.9	92.2	10.6	37.4	9.2	18.9	78.6	12.67	0.5	28.9	83
Romania	16.4	18.2	4.9	60.2	30	58.7	78.6	15.3	25.5	16.8	9.3	85.7	4.4	22.4	11.5	68.1
Slovenia	15.3	14.5	2.9	60.9	27	58.1	92.1	4.6	44.1	8.8	2.3	89.8	0.7	0.1	59.2	63.8
Slovakia	13.8	10.5	2.7	56.2	25	58.7	77.8	8.3	39.2	14.5	7.8	77.7	0.39	1.3	38.5	45.5
Finland	5.1	12.8	4.7	56.4	15	59	88.8	7.3	42	9.5	1.8	69.6	0.61	0.2	43.5	61.8
Sweden	5.8	17	1.4	73.3	7	51.3	95.6	6.5	48.4	6.3	1.9	68.3	0.69	0	46.6	77.1

Table A2. Performance matrix of the EU countries.

	EMPLOYMENT				EQUALITY						ENVIRONMENT					
	8.3 Employment Rate by Sex	**1.41 In Work at Risk of Poverty Rate**	**8.6 People Killed in Accidents at Work, by Sex**	**5.4 Inactive Population Due to Caring Responsibilities by Sex**	**1.1 People at Risk of Poverty or Social Exclusion**	**10.6 Asylum Applications by State of Procedure**	**5.2 Gender pay Gap in Unadjusted Form**	**5.3 Gender Employment Gap**	**5.6 Positions Held by Women in Senior Management Positions**	**10.41 Income Distribution**	**13.1 Greenhouse Gas Emissions by Source Sector**	**12.3 Average CO_2 Emissions per km from New Passenger Cars**	**7.4 Share of Renewable Energy in Gross Final Energy Consumption by Sector**	**15.1 Share of Forest Area**	**15.2 Surface of Terrestrial Sites Designated under Natura 2000**	**15.41 Soil Sealing Index**
Belgium	70.5	4.8	1.91	17.2	19.5	2011	5.8	8	35.9	3.61	10.5	121.5	9.924	24.3	3891	1917
Bulgaria	74.7	8.9	3.37	29.9	32.8	297	14.1	9	18.5	8.1	6.8	137.6	21.564	48	38,728	1012
Czechia	80.3	3.5	2.01	28.8	12.5	147	18.9	15	18.2	3.34	12.9	128.7	16.244	37.9	11,148	1941
Denmark	78.3	6.3	1.43	4.9	16.3	448	14	7.2	30	4.09	8.6	111.9	37.204	16.4	3594	1285
Germany	80.6	8	0.79	19.3	17.4	1714	19.2	8	35.6	4.89	9.9	131.2	17.354	32.4	55,228	15,847
Estonia	80.2	10	2.51	28.8	24.3	75	21.7	7.7	9.4	5.08	10.7	130.1	31.889	58.3	8106	203
Ireland	75.1	4.3	1.77	37.7	20.6	961	11.3	12.4	26	4.03	13.7	114	11.984	19	9226	698
Greece	61.2	10.2	0.92	19	30	6987	10.4	20	10.3	5.11	8	115.6	19.677	47.5	35,982	1337
Spain	68	12.7	1.78	28.8	25.3	2444	11.9	11.9	26.4	5.94	6.3	121.3	18.362	41.2	138,111	6402
France	72.3	7.4	3.53	10.9	17.9	2056	16.5	5.9	45.2	4.27	6.3	113.7	17.216	32.8	70,875	12,474
Croatia	66.7	5.1	2.96	24	23.3	311	11.5	10.5	27	4.76	4.6	119.4	28.466	58	20,716	719
Italy	63.5	11.8	2.1	27.9	25.6	586	4.7	19.6	36.1	6.01	6.5	119.4	18.181	37	57,258	8315
Cyprus	75.7	6.7	2.45	42.9	22.3	14,394	10.1	11.6	9.4	4.58	10.8	126.8	13.8	43.2	1669	205
Latvia	77.4	8.5	2.78	22.3	27.3	94	21.2	3.8	31.7	6.54	5.5	127.9	40.975	56.2	7447	261
Lithuania	78.2	7.9	3.01	18.7	26.3	224	13.3	1.6	12	6.44	5.5	132	25.461	39.6	8136	507
Luxembourg	72.8	12.1	3.13	16.4	20.6	3548	1.3	9.1	13.1	5.34	19.7	133	7.047	35.5	702	116
Hungary	75.3	8.4	2.09	23.4	18.9	48	18.2	15.5	12.9	4.23	6.1	131.8	12.614	26.1	19,949	1440
Malta	76.8	6.5	1.18	37.7	20.1	7965	11.6	20.7	10	4.18	5.3	105.3	8.488	10.4	42	53
Netherlands	80.1	5.5	0.48	11.2	16.5	1296	14.6	9.3	34.2	3.94	11.4	98.4	8.768	10.9	5522	2859
Austria	76.8	7.6	2.46	18.4	16.9	1237	19.9	8.8	31.3	4.17	8.8	125.5	33.626	46.4	12,895	1523
Poland	73	9.7	1.1	30.7	18.2	73	8.5	15.4	23.5	4.37	10	132	12.164	36.4	61,168	4725
Portugal	76.1	10.8	2.12	15.9	21.6	169	10.6	7.2	24.6	5.16	5.8	109.4	30.619	49.9	18,968	2008
Romania	70.9	15.7	3	26.2	31.2	127	3.3	19	12.6	7.08	4.3	124.3	24.29	35.5	54,214	2131
Slovenia	76.4	4.5	1.61	12.4	14.4	1731	7.9	6.8	24.6	3.39	8.2	123.7	21.974	62.5	7672	348
Slovakia	73.4	4.4	1.5	26.4	16.4	39	18.4	13	29.1	3.34	6.2	133.4	16.894	48.6	14,633	767
Finland	77.2	2.9	0.99	12.1	15.6	443	16.6	2.7	34.2	3.69	7.4	115.3	43.081	69.9	42,495	1436
Sweden	82.1	7.8	0.72	6.1	18.8	2250	11.8	4.7	37.5	4.33	1.8	119.7	56.391	67	55,611	1864

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