***DETUROPE** – THE CENTRAL EUROPEAN JOURNAL OF REGIONAL DEVELOPMENT AND TOURISM*
Vol. 16 Issue 1 2024 *ISSN 1821-2506*

Original scientific paper

MEASURING SUSTAINABLE DEVELOPMENT IN THE EUROPEAN UNION BASED ON THE 2030 AGENDA INDICATORS

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Cite this article: Kozma, D.E. (2024). Measuring Sustainable Development In The European Union Based On The 2030 Agenda Indicators. *Deturope*, 16(1), 21-42.

Abstract

The author's research was based on the indicators of the 2030 Agenda for Sustainable Development, which are used to explore the measurement of sustainable development in the European Union for the period 2014-2018. Various statistical and econometric methods were used in the quantitative research, such as factor analysis, correlation analysis, and scale-alignment transformation. The main objective of the research is to show the diversity of the possibilities for measuring sustainable development and the extent to which the selected methods can reduce the indicators in the 2030 Agenda database. The results suggest that the set of indicators for the 2030 Agenda can be reduced in size without significantly reducing the information content. The established sustainable development factors show a strong relationship with GDP and HDI indicators. Sustainable development can be analyzed using a single composite indicator (CSDGI) for the five years under study. The assessment of sustainable development indicators, together with these methods, provides a new methodological basis for measuring sustainability.

Keywords: the 2030 Agenda, European Union, sustainable development, database

INTRODUCTION

Achieving sustainability and sustainable development is a huge challenge for humanity. This is because human activities and behaviour have contributed in an integral way to the development of unsustainable processes. The population explosion of the 20th century, globalization and economic growth triggered a crisis that created a system of interconnected problems in nature, economy and society. In our daily lives, be it in our personal lives or in the world of work, sustainable development as a concept and a definition in most disciplines, emerges significantly in terms of its diffusion from the 20th century onwards (Kerekes & Fogarassy, 2007). Also, this era is mentioned in a study by Silva et al. (2014), where we read that the concern for environmental issues and impacts can be attributed to developments in the post-World War II period. The war has not only had an impact on the environment, but also in terms of widening disparities in development between countries, which has been paralleled by changes in living standards (Faragó, 2015). Minimal attention has been paid to the waste and by-products of industrial production and the irreversible processes they generate. The description of these factors contributes to the essential study of sustainable development, both conceptually and in terms of measurability.

Defining the concept of sustainable development, exploring the relationship between the dimensions and measuring the progress of countries is a complex and careful task. Conferences and conventions held over the decades – as well as the various framework strategies at UN and EU level – have contributed to measuring progress towards sustainable development and quantifying and monitoring progress towards the targets. In this research, the author examines the measurement of sustainable development, sustainability based on the objectives of the current framework strategy *"Transforming our world: the 2030 Agenda for Sustainable Development"* (hereinafter: Agenda 2030) and the related indicator framework. The main objective of the research is to measure sustainable development based on the 2030 Agenda using different mathematical-statistical-econometric methods, while at the same time, the reduction of the indicators is also implemented. An additional aim is to explore the relationship between the factors created and the GDP, HDI indicators and to be able to assess the performance of the EU Member States in sustainable development by creating a single indicator. The new outcome of the research is the development of a methodology using applied methods. This should facilitate future research on measuring sustainable development.

THEORETICAL BACKGROUND

Sustainable development and sustainability is for everyone. There is hardly a single person on the planet who knows all its concepts and contents. The main reason is that countless researchers have developed their own definitions to describe the concept. Of course, in this case we cannot forget the concept of the Brundtland Commission (WCED), which was introduced in the 1980s as follows*: "... development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (WCED, 1987, p. 16). In fact, we need to achieve a development that meets the needs of those living today without compromising the provision for future generations. We might ask, then, what exactly do we need to maintain? In the first place, utility, physical performance and natural capital are necessary to achieve sustainability (Daly, 2002). It is necessary to sustain the community and society, and to support life.

Before the concept was formulated, a number of conferences and conventions have sought to focus on the concept of sustainability since 1972. Before discussing these, however, we should not forget Rachel Carson's seminal book *"Silent Spring"*, which recognized the powerful impact of pesticides on the environment (Carson, 1962). After that, some kind of change was set in motion, which the Club of Rome tried to carry forward. They identified global problems, analyzed them and published a plan of action to solve them. The emergence of sustainability was basically attributed to the fact that humanity must stop uncontrolled quantitative growth and thus be able to prevent catastrophe (Szabó, 2008).

The first "real" sustainability-based conference was held in Stockholm in 1972, which launched the conceptual history of sustainable development (Zolcerova, 2016). General principles such as environmental preservation, eco-development and the right to a healthy human life were discussed. A central task of the World Commission on Environment and Development (Brundtland Commission) was to examine the industrial performance of developing countries to see if they could ever match that of developed countries. Through their work, they have strengthened the definition of development as being within ecological limits (Moran et al., 2008). Their report has sought to address the problems facing the world through the complexity of the three dimensions of sustainable development (Burjánné Botos, 2002).

Further conferences were held in the period that followed, with the focus remaining on catching up with developing countries and the need to address the problems in the dimensions together rather than aspect by aspect. The 1992 UN conference produced the first Sustainable Development Action Plan (Agenda 21), which set out the principles to be addressed, the measures needed to make the transition and the series of steps needed to achieve it (Endl & Sedlacko, 2012). Adopted in 2000, the Millennium Development Goals, also known as "the world's biggest promise", carried forward the approach of previous conferences and set as their main goal the improvement of the lives of the world's poor and sustainable development (Griggs et al., 2014). 8 goals, 18 sub-goals and 48 indicators were identified for follow-up, which, even after the programme's closure, failed to address the world's sustainable development gaps. Of the 8 goals, 3.5 were achieved and developing countries were still at a significant disadvantage compared to developed countries.

The Johannesburg conference in 2002 was needed to assess progress using indicators as part of the monitoring process (Endl & Sedlacko, 2012). Building on the experience of the previous conferences, the Rio+20 World Conference on Sustainable Development was held in Rio de Janeiro from 20 to 22 June 2012, with the aim in addition to broadening international dialogue, to promote and prepare proposals for the establishment of sustainable development (Raworth, 2012). In the author's opinion, the greatest achievement is the initiative that emerged from the conference to establish the Sustainable Development Goals (SDGs), which will replace the Millennium Development Goals (MDGs).

Agenda 2030 is the most recent framework for sustainable development in force, adopted by the United Nations in September 2015 under Resolution A/RES/70/01 (Walsh et al., 2020). In January 2013, UN member states established an Open Working Group to promote sustainable development (Jancsovszka, 2016). The work of the group resulted in the creation of 17 Sustainable Development Goals (SDGs), complemented by 169 additional targets (de Vries, 2015), creating a unique opportunity to create a coherent framework to keep the world on a sustainable path to 2030. It aims to address the challenges facing humanity, recognizing the importance of eradicating poverty (Miola & Schlitz, 2019). The key objective of the SDGs is to stimulate efforts, guide humanity towards sustainability and address the challenges.

The author's research is based on the SDG indicators adopted in March 2016, which can also be seen as a key monitoring element and the basis for the review mechanism (Eurostat, 2018). In total, 244 indicators have been developed for the 17 SDGs to measure progress towards sustainability (Galli et al., 2018). Compared to the MDGs, the innovation lies in the comprehensive assessment, where not only economic stability and environmental integrity but also social equity of well-being are taken into account (Kynčlová et al., 2020). A critical element of the system lies in the overlap between the goals, as the achievement of some goals may trigger ripple effects while achieving others. Understanding the interactions between these goals requires far more detailed information (Weitz et al., 2018). Achieving past and present sustainable development goals is a major challenge for the world's people and countries. For the period 2015-2030, the 17 Sustainable Development Goals (SDGs) represent an ambitious step towards sustainability, as they can provide a much broader picture of the results achieved. The conferences and conventions that preceded it carry the vision forward and reflect an even greater effort by the world to tackle the issues.

Research questions and hypothesis

The quantitative research is based on a database covering all the 17 Sustainable Development Goals (SDGs) of the 2030 Agenda which were downloaded from the Eurostat website (https://ec.europa.eu/eurostat/web/sdi/database). The common feature is that the indicators are all high-level variables, measured on a metric scale, and are therefore well suited to demonstrate the main objective and to implement the chosen methods. The research question is: *"what methods can be used to measure progress towards the SDGs using the Agenda 2030 database?"* In this context, the author of the study has made the following assumptions:

H1: The complex set of indicators for the 17 Sustainable Development Goals (SDGs) of the 2030 Agenda can be well described by fewer indicators in case of the 28 Member States of the European Union.

H2: A statistically significant relationship between the SDGs and GDP, HDI indicators can be found in most cases.

H3: The set of indicators covering the 17 SDG's of the 2030 Agenda can be used to create composite indicators that provide a good description of sustainable development for the 28 EU Member States. By creating them, they will contribute to the characterization and easier interpretation of sustainable development in a single number and to easier measurement of progress.

In all cases, the "goodness" of the methods used in the research was evident in their implementation, i.e. they served their purpose well by meeting the requirements attached to them. In the present case, more possibilities and a simpler interpretation of the measurement of sustainable development were made possible.

DATA AND METHODS

The author's research is based on the indicators of the 2030 Agenda, which are used to explore the measurement of sustainable development in the European Union for the period 2014-2018. It is characteristic of the individual sustainability goals that there is often overlap between them, which is also reflected in the fact that an indicator appears for several goals. In terms of database availability, the indicators of the framework strategy are available on Eurostat's website (https://ec.europa.eu/eurostat/web/sdi/database), collected according to the 17 SDGs, with a minimum time span of 5-10 years. This is the only system that includes statistical data from all 28 Member States and thus provides the required data. In total, 347 indicators were examined, including sub-indicators over a five-year period. The importance of the system also lies in the fact that the indicators have been developed on the basis of the same methodology.

Sustainable development was measured in this study using several statistical-econometric methods for example Factor analysis with Principal Component Analysis, correlation analysis and scale-alignment transformation. In case of FA, the main objective was to reduce the number of indicators for the 17 SDGs in such a way that the author could create as few factors as possible and thus draw conclusions that were close to the original ones with a minimum loss of information. In this case the method of factorization is PCA. Correlation analysis showed the closeness of the relationship of the factors created in the factor analysis with GDP and HDI indicators. The scale-alignment transformation has helped to create a composite indicator for the three dimensions of sustainable development.

Statistical analysis of multivariate compositional data, as seen here, is often a contentious issue, but it is nevertheless essential for quantitative analysis of the growing number of large-scale data sets. The use of various multivariate statistical techniques such as PCA or FA helps to better interpret the results and makes the process less subjective (Tripathi & Singal, 2019). Research using FA and PCA is summarised in Tab. 1.

Table 1 Data reduction-based studies published in the field of sustainability

Name of the authors	Year	Aim	Subject of the study	Applied method(s)
Filzmoser et al.	2009	methodological presentation through a geochemical example	769 agricultural soil sample	FA, PCA
Mahdinia et al.	2018	propose an algorithm as a framework that takes into account the different number of indicators in the different dimensions and divisions of transport sustainability	-	PCA, FA
Mainali et al.	2015	introducing a methodology to assess the sustainability performance of energy technologies in rural electricity	11 indicators	PCA, FA
Mascarenhas et al.	2015	identify a set of sustainability indicators for strategic monitoring of regional territorial plans	Algarve Regional Spatial Plan (130 indicators)	PCA, FA
Nardo et al.	2005	methodological study	there are no specific indicators	PCA, FA, Gronbach Coefficient Alfa, cluster analysis

Table 1 (continued)

Name of the authors	Year	Aim	Subject of the study	Applied method(s)
Reisi et al.	2014	review the main initiatives presented in the literature that measure sustainable transport	9 sustainability indicators	PCA, FA
Riccioli et al.	2020	examine the SFM (Sustainable Forest Management) indicators	6 SFM indicators	PCA, FA
Zarrabi & Fallahi	2014	sustainability rate assessment	Tehran Province, Iraq	FA, cluster analysis

Source: own editing

In their study, Mascarenhas et al. (2015) used PCA to reduce the number of indicators in the regional plan of one region of Portugal (Algarve) that contribute to sustainable development. The work of the other authors can be divided in terms of whether they have carried out a methodological study, such as Reisi et al. (2014), Nardo et al. (2005), Filzmoser et al. (2009) or have used the method specifically to analyze indicators of sustainability (Zarrabi & Fallahi, 2014; Riccioli et al., 2020; Mainali et al., 2015).

Quantitative analyses were carried out using IBM SPSS and Microsoft Excel. The indicators are all high level variables and therefore metric and therefore suitable for implementing different and complex methods. The EU Sustainable Development Strategy was in force from 2014 to 2015, and the 2030 Agenda was adopted in September 2015. Regardless of this division, the indicators were already available under the EU strategy and thus became a coherent whole with the 2030 Agenda.

The different methods used meant examining different numbers of data points. For the 17 SDGs, the data content of the factor analysis was 9,632 data points with sub-indicators, which is 48,160 over the five-year period. Of course, it should be borne in mind that there are indicators *(such as EU imports from developing countries)* that are achievable for several targets, but there are also indicators where the criterion of measurability is not feasible due to their aggregate nature *(global average ocean surface acidity).* The existence of relationships was further explored by examining the relationship between factors from Factor Analysis (hereinafter: FA) and GDP, HDI indicators. In this case, the author performed FA for 52 for 2014, 61 for 2015, 55 for 2016, 62 for 2017 and last but not least, 66 factors for 2018.

To characterize sustainable development by a single number, the author has created composite indicators at Member State level based on the three dimensions (economic, social, environment), or one that includes all aspects. To create the composite indicators, the author used a scale-alignment transformation to ensure that the magnitude and content of the underlying indicators are preserved. In the case of economic, social and environmental targets, the author did not allow that if an indicator appears for more than one target, it can be used for all of them, so they appear only once in the creation of composite indicators. Thus, for one year, the author has analyzed and created composite indicators for 2,044 data units for the economic dimension (73 indicators), 2,072 for the environmental dimension (74 indicators) and 3,136 for the social dimension (112 indicators).

RESULTS

Capturing sustainable development and sustainability at a theoretical and practical level, and interpreting the concept at a theoretical and practical level, involves a number of difficulties and challenges. The 2030 Agenda, as formulated and launched by the UN, makes a significant contribution to making sustainable development tangible and to quantifying and measuring the goals and targets that have been set over the years. The selection and analysis of indicators measured at the appropriate scale is a key issue in helping to achieve this research objective. In the following, the author will present the results obtained for the different methods.

Factor analysis-based data reduction

The complexity of sustainability requires easier and better interpretability, which can only be achieved by reducing the set of indicators. In the field of indicators and within this context, data reduction, there are two similar methods that belong to the same methodological *"family"*. These two methods are Factor Analysis (FA) and Principal Component Analysis (PCA). In terms of similarity, both methods are based on the principle of data reduction and within this, the method of factorization is PCA, where the method is transformed back into factor analysis by rotating the factors.

In this research, the author sought to reduce the number of indicators for the 17 SDGs by FA. The main objective in this case is to generate the fewest number of factors to get a clearer picture of the indicator set, i.e. to reduce the number of indicators, but also to minimize the loss of information and to draw the same conclusions as the original. The present research covered five years and for illustrative purposes, the author presents the results of *"Decent work and economic growth (Goal 8)"* for the year 2018. The suitability of the variables included in the study (26 indicators) was determined on the basis of the KMO (Kaiser – Meyer – Olkin) criterion, with a minimum acceptance threshold of 0.5, so that a value below this threshold cannot be accepted. For all SDGs, the value of the KMO varied between 0.531 and 0.739. In case of the presented SDG 8, this value was 0.720, which is considered to be good-enough, so the method can be implemented on the indicators. During the research, the author did not change the default settings of the SPSS program to determine the number of factors, nor did she change the number of interactions the algorithm should perform. Only the method of implementation was chosen (PCA).

The question that arises in the next step is whether or not the variables are adequately characterized by the factor in question. For this very reason, great attention must be paid to the magnitude of the values, which can be seen by measuring the coefficient of variance (how much explained variance the factors contain). The four factors created for purpose 8 retain 75.70% of the information, which is also the total explanatory power. The criterion is that the information content should be at least 50%. Before drawing the final conclusion, the rotation of the factors must be taken into account. In the tests, the author used a *"promax"* method, which allows for an even better interpretation of the factors and maximizes the variance. It can take values between -1 and 1. Factors could include indicators whose sample item number has the appropriate factor weight.

The KMO and Bartlett's test shows the sample element number, which in this case is 78, so the factor weight must be at least 0.625 for the sample to be significant. Of the total 26 indicators, 12 indicators remain as factor content (for example: "total employment rate", "long-term unemployment rate", "the proportion of young people not in education nor in training", "resource productivity", "GDP per capita" etc.). Indeed, the other indicators were dropped when testing for communality. The 17 SDGs have been analyzed by the author according to the three SDG aspects for the period 2014 to 2018, whose aggregated data for 2018 are shown in Tab. 2.

Table 2 Data reduction-based studies published in the field of sustainability

	SDG 1	SDG 2	SDG 3	SDG 4	SDG 5	SDG 6	SDG 7	SDG 8	SDG 9
KMO	0.579	0.604	0.725	0.684	0.647	0.563	0.680	0.720	0.604
Information content (%)	89.411	78.920	77.863	82.584	82.399	75.335	70.625	75.704	67.125
Level of significance	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Number of factors	5	4	4	3	5	3	3	4	3
Number of initial/final indicators	24/12	18/6	31/15	21/6	24/13	16/4	21/7	26/12	22/4
	SDG 10	SDG 11	SDG 12	SDG 13	SDG 14	SDG 15	SDG 16	SDG 17	
KMO	0.736	0.641	0.650	0.624	0.531	0.638	0.709	0.707	
Information content (%)	86.785	75.900	74.956	77.017	88.242	80.481	84.869	80.369	
Level of significance	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
Number of factors	5	4	4	4	3	4	4	4	
Number of initial/final indicators	23/15	22/14	22/11	15/5	7/4	14/9	25/13	16/12	
	In total			347 initial indicators / 162 final indicators					

Source: own editing

The FA, which performs data reduction and indicator reduction, is an excellent method to prove the hypothesis (*H1. The complex set of indicators for the 17 Sustainable Development Goals (SDGs) of the 2030 Agenda can be well described by fewer indicators in case of the 28 Member States of the European Union)*, as it can illustrate the complexity of indicators with far fewer indicators. Overall, it can be concluded that the criteria of the method is fulfilled without exception in the different steps, the information content is above 50% in all respects, and the KMO criterion is above 0.5. The SPSS program generated between 2 and 6 factors for the five years, with the corresponding indicators selected according to the factor weights. The purpose of the method was fulfilled, so FA is an excellent way to reduce the size of the database, and it is now easier to draw conclusions from the "new" database, measuring the performance of EU Member States. The remaining variables express the SDGs more emphatically with the complexity of the information content.

Relationship between factors and GDP, HDI indicators

The relationship between the factors generated by the FA method used in the first hypothesis was examined in terms of the relationship with GDP and the HDI indicator. More specifically, the question is whether there is a relationship between them and, if so, what kind of relationship. To prove the second hypothesis *(H2. A statistically significant relationship between the SDGs and GDP, HDI indicators can be found in most cases)*, the author used correlation analysis, which shows what the relationship is and the degree of closeness. Correlation analysis quantifies the relationships between variables that can be measured at a high level of measurement (Molnár, 2015). The Pearson correlation coefficient (which can take a value between -1 and 1) can be used to determine the degree of closeness. A property of the method is that it is not necessary to determine the dependent and independent variables, as it is symmetric and thus the variables are interchangeable.

The author's research has drawn conclusions for the five years under study in the light of the factors and the GDP, HDI indicators. The reliability of the conclusions is determined by the level of significance, which is acceptable below 5%. By theme or target, the FA has produced 66 factors for 2018, with a wide range of relationships between the two selected indicators. In several cases, a medium to strong correlation was found between the factor and GDP and between the factor and the HDI. Significant relationships with positive or negative signs for GDP are shown in Tab. 3. For the factors shown in the table, SDG_01_01 indicates that the first factor is significant at Goal 1, while SDG_08_02 is the second factor at Goal 8. The interpretation is the same for significant factors and HDI.

Table 3 Significant GDP - factor relationships for the year 2018

Name of the factor	Correlation coefficient	Name of the factor	Correlation coefficient
SDG_01_ No poverty		SDG_08_02	0.813***
SDG_01_02	-0.493***	SDG_08_03	-0.357*
SDG_01_03	-0.431*	SDG_09 Industry, innovation and infrastruc.	
SDG_02_ Zero hunger		SDG_09_01	0.430**
SDG_02_02	0.427**	SDG_09_02	-0.492***
SDG_02_04	0.483***	SDG_10_ Reduced inequalities	
SDG_03_ Good health and well-being		SDG_10_02	0.916***
SDG_03_01	-0.540***	SDG_10_05	-0.385*
SDG_03_02	-0.517***	SDG_11_Sustainable cities and communities	
SDG_03_03	-0.565***	SDG_11_01	-0.449**
SDG_04_Quality education		SDG_11_03	-0.531***
SDG_04_01	-0.458**	SDG_12_ Responsible consmuption and prod.	
SDG_04_02	0.657***	SDG_12_01	0.567***
SDG_05_Gender equality		SDG_12_04	0.733***
SDG_05_01	0.422**	SDG_13_ Climate action	
SDG_05_02	0.491***	SDG_13_02	0.348*
SDG_06_Clean water and sanitation		SDG_13_03	0.544***
SDG_06_02	-0.426*	SDG_16_Peace, justice and strong institutions	
SDG_06_03	-0.362*	SDG_16_01	0.779***
SDG_07_Affordable and clean energy		SDG_16_03	-0.498***
SDG_07_01	0.685***	SDG_17_ Partnership for goals	
SDG_07_03	0.426*	SDG_17_01	0.351*
SDG_08_Decent work and economic growth		SDG_17_02	0.696***
*The significance level of the correlation coefficient *: 5% > p < 2,5%; **: 2,4% > p < 1,1%, ***: 1% > p < 0%*			

Source: own editing

It can be seen that factor-GDP pairs with different strengths and directions of relationship have been created for the different SDGs. In the case of the goals describing the social dimension (SDG_03_03; SDG_04_01), a negative correlation can be seen, due to the fact that they take away from the value of GDP and add nothing to it; and for the factors that describe the health of people and the development of society, it can be seen that health expenditure accounts for a very large proportion of GDP. In the case of the economic aspect (SDG_08_02), there is an explicit link with GDP, since some indicators (included in the factor) are based on GDP itself. The existence of a close, positive correlation is due to this factor. From the environmental point of view, the factors typically include indicators (e.g. primary and final energy consumption) whose correlation is due to a long-term relationship. Research has shown/shows that energy generates economic growth in the long run. The moderately negative relationship of air pollution indicators with GDP (SDG_11_03) can be explained by the fact that the economy is heavily burdened by the damage caused by various pollutants. The economic damage results from the following factors: illnesses, deaths, medical treatments and the number of hours lost from work.

For the HDI indicator, the author of the study examined the same 66 factors as for GDP. Again, in terms of the type of relationship, significant and non-significant; positive and negative; loose, medium and close relationships were found. Cases with a loose correlation coefficient were largely excluded from the analysis due to the level of significance, but those with a corresponding value showed a detectable relationship between the factors and HDI. The relationship between the factors, which are then broken down into the three aspects of sustainable development, and the HDI indicator is also complex. Significant relationships with positive or negative signs for HDI are shown in Tab. 4.

Table 4 Significant HDI - factor relationships for the year 2018

Name of the factor	Correlation coefficient	Name of the factor	Correlation coefficient
SDG_01_ No poverty		SDG_08_03	-0.465**
SDG_01_02	-0.733***	SDG_09 Industry, innovation and infrastruc.	
SDG_01_03	-0.376*	SDG_09_02	0.639***
SDG_01_04	-0.441**	SDG_09_03	0.398*
SDG_02_ Zero hunger		SDG_10_ Reduced inequalities	
SDG_02_02	0.544***	SDG_10_01	0.444**
SDG_02_03	-0.575***	SDG_10_02	0.651***
SDG_02_04	0.676***	SDG_10_03	-0.521***
SDG_03_ Good health and well-being		SDG_11_Sustainable cities and communities	
SDG_03_01	-0.671***	SDG_11_01	-0.588***
SDG_03_02	-0.584***	SDG_11_02	0.411*
SDG_03_03	-0.819***	SDG_11_03	-0.653***
SDG_04_Quality education		SDG_12_ Responsible consmuption and prod.	
SDG_04_01	-0.738***	SDG_12_01	0.551***
SDG_04_02	0.654***	SDG_12_04	0.632***
SDG_05_Gender equality		SDG_13_ Climate action	
SDG_05_01	0.424**	SDG_13_02	0.392*
SDG_05_02	0.502***	SDG_13_03	0.409*
SDG_05_03	0.427**	SDG_14_Life below water	
SDG_06_Clean water and sanitation		SDG_14_01	0.385*
SDG_06_02	-0.483***	SDG_16_Peace, justice and strong institutions	
SDG_06_03	-0.398*	SDG_16_01	0.853***
SDG_07_Affordable and clean energy		SDG_16_03	-0.454**
SDG_07_01	0.685***	SDG_17_ Partnership for goals	
SDG_08_Decent work and economic growth		SDG_17_01	0.459**
SDG_08_01	-0.430**	SDG_17_02	0.523***
SDG_08_02	0.738***		
The significance level of the correlation coefficient **: 5% > p < 2,5%; **: 2,4% > p < 1,1%, ***: 1% > p < 0%*			

Source: own editing

In this case, however, the complexity of the indicator used as a basis for comparison becomes apparent, in that life expectancy at birth, educational attainment and a decent standard of living (GDP at purchasing power parity) are also integral components of the HDI. Indicators covering social factors are characterized by the fact that they can be found to be inversely related, even if they are also components of the HDI. In the case of the economic dimension (SDG_08_02), the strong relationship is due to the correlation with GDP, which is also characteristic of the correlations with the environmental dimension.

Overall, it can be concluded that for the year 2018, there are positive or negative, significant or non-significant, loose, medium and strong relationships between the factors and GDP and HDI indicators. For GDP, 31 of the 66 factors have a statistically significant relationship, while for the remaining 35 no relationship can be interpreted. In the 2014 study, there is a 50/50 ratio (26-26) of significant to non-significant factors, compared to 32-29 in 2015. The relationship between indicators and GDP for 2016 has 30 significant and 25 non-significant relationships, while 2017 shows a ratio of 32/30. In contrast, for HDI, a significant relationship is shown for 37 out of 66 factors. Compared to the other years studied, in 2014, 36 out of 52 factors had a linear positive or negative relationship, while in 2015 the ratio is 38/23. In 2016, 35 out of 55 factors have positive and negative significant cases, while 2017 data shows a ratio of 36/26. These results show that each year there are more factor - HDI pairs with a significant relationship, so significant results could be generated.

Composite indicator for sustainable development

It may often seem simpler to examine a single indicator than to grapple with identifying trends in several indicators of a similar nature, which are significantly more useful in comparing the performance of several Member States simultaneously (Li et al., 2012). The way in which sustainable development concepts appear in a myriad of disciplines can make it difficult to assess closely related indicators. A further complication is that sustainability processes can vary in space and time, often requiring the integrity of multiple indicators to create a single composite index (Cîrstea et al., 2018). A study by Zhou et al. (2007) concludes that they are increasingly being used by international organizations for performance monitoring, public communication and policy analysis. One might ask what exactly the term composite indicators means.

A summary table (Tab. 5) is presented to familiarise the reader with the main areas for the creation of composite indicators for sustainable development and to identify the newly created indicators and the methodology used.

Table 5 Composite indicators for sustainable development

Name of the authors	Year	Aim	Name of the composite indicator	Applied method(s)
Bolcárová & Kološta	2015	create an aggregate indicator of sustainable development from the EU SDIs indicators	(aSDI) Aggregated Sustainable Development Index	PCA
Cîrstea et al.	2018	create an index that represents the sustainability of renewable energy	RESI – Renewable Energy Sustainability Index	FA, PCA
Foa & Tanner	2012	an introduction to the methodology of the social development indicators	HDI, GEM, WGI	methodological
Mazziotta & Pareto	2013	general guidelines for the development and compilation of the composite index	there is no specific composite indicator	simple arithmetic mean, PCA, Multicriteria Analysis
Saisana & Philippas	2012	sustainable society assessment using the composite index	SSI – Sustainable Society Index)	indicator selection, missing data, normalization, weighting, aggregation

Source: own editing

In the author's research, a scale-alignment transformation was used to create composite indicators by dimension and their standardized versions. This method should be used when the object of the study contains several variables, because it allows to combine the scale and size of the variables. Creating the composite indicator consisted of a series of steps defined by dimension. The European Union's sustainable development database itself defined the phenomenon, selected and then defined a set of indicators for the SDGs. The next step was to homogenize the data using a scale-alignment transformation (the variables are transformed to values between 0 and 1), a method that is appropriate for cases involving several variables. The variables are scaled (i.e. "normalized") by subtracting the mininum value of the variable from the actual value of the variable and then dividing this difference by the range of the variable (i.e. the difference between the maximum and minimum values) (Feuerstahler & Wilson, 2021). Last but not least, the author did not weight the homogenized data, but simply aggregated them and, as a last step, a composite indicator was created.

According to this research, this method was performed by the author for 112 social, 73 economic and 74 environmental indicators. The composite indicators ($CSDGI_{Economic2018}$; $CSDGI_{Environmental}2018$; $CSDGI_{Social2018}$) for 2018, which were created separately for the three pillars of sustainable development, are presented in Tab. 6.

Table 6 Composite indicators based on the three pillars of sustainable development

	Countries	$CSDGI_{Eco2018}$	Countries	$CSDGI_{Env2018}$	Countries	$CSDGI_{Soc2018}$
28	Greece	1.0503	Bulgaria	-8.4555	Romania	-33.4009
27	Romania	2.8600	Poland	-7.1848	Bulgaria	-32.8986
26	Bulgaria	3.0660	Luxembourg	-6.9889	Latvia	-23.1744
25	Croatia	6.1890	Belgium	-5.9205	Italy	-21.2999
24	Lithuania	7.5031	Estonia	-5.7269	Greece	-20.3406
23	Spain	7.5698	Lithuania	-5.1564	Croatia	-19.0202
22	Portugal	8.3536	Malta	-5.1124	Lithuania	-17.2479
21	Slovakia	8.6832	Romania	-5.0739	Slovakia	-15.5858
20	Italy	8.9131	Czechia	-3.3148	Hungary	-15.4634
19	Poland	8.9401	Hungary	-3.2510	Portugal	-14.6260
18	Cyprus	9.6014	Cyprus	-2.9041	Poland	-12.7871
17	Latvia	10.5349	Slovakia	-2.8281	Spain	-12.7617
16	Estonia	10.6080	Germany	-2.6313	Cyprus	-11.2110
15	Hungary	12.2809	Latvia	-2.1027	UK	-8.9617
14	Slovenia	13.3239	Netherlands	-1.7218	Germany	-8.6248
13	Malta	13.6450	Finland	-1.7166	France	-8.2907
12	Ireland	13.8945	Austria	-1.1093	Czechia	-8.2203
11	Luxembourg	16.0685	Portugal	-0.6699	Estonia	-7.7039
10	UK	16.5903	Italy	-0.4505	Malta	-5.9824
9	Czechia	16.8120	Greece	-0.1101	Belgium	-5.0405
8	Austria	17.6194	Slovenia	-0.0865	Slovenia	-3.8143
7	France	17.6339	Croatia	0.0175	Luxembourg	0.3175
6	Belgium	17.7023	Spain	0.1384	Austria	1.4871
5	Finland	18.5915	Ireland	0.3143	Netherlands	1.5897
4	Sweden	20.5654	UK	0.7104	Denmark	1.7553
3	Denmark	20.5805	Denmark	1.6839	Ireland	2.5091
2	Germany	26.3618	Sweden	1.9376	Finland	4.1619
1	Netherlands	27.9187	France	2.3387	Sweden	7.3470

Source: own editing

By ranking aggregated indicators in this way, they are already able to draw conclusions at the appropriate level at EU level. This complex information gives us a picture of the situation in the 28 Member States at environmental, social and economic level. The lowest ranking Member States have performed best, while the highest-ranking Member States have performed worst in terms of the Agenda 2030 indicators. Two countries, Denmark and Sweden, are true pioneers in all three pillars, each ranking in the top five. They have shown a strong commitment to the vision of sustainability and sustainable development and have been working from the very beginning to integrate the objectives of the sustainability framework strategies into their daily lives and to implement the targets. For the composite indicators, the content of the SDGs is fully reflected in the indicators, as they are invariably integrated into the process of their creation. As such, they convey the same meaning as if the indicators were presented separately per goal.

From the composite indicators describing the three aspects of sustainable development presented above, the author of the study created the CSDGI indicator measuring all pillars together, based on the same methodology. The calculation method and steps to generate the CSDGI indicator differ from those of the dimension-by-dimension indicators. In this case, the values of the economic, environmental, and social composite indicators were added together by the country and then re-ranked.

Examining the rankings for the period 2014 to 2018, it can be concluded that Sweden leads the field in all cases. The top five ranking includes Sweden, Denmark, the Netherlands, Finland, Germany and Austria. The rankings are identical in three of the years examined (2014, 2015 and 2017), while the composition is different in 2016 and 2018. Sweden's leadership is not without reason, as it has appointed a committee and a delegation to implement the 2030 Agenda at the national level. In the case of the Netherlands, the policy to achieve sustainable development indicates that national efforts to achieve the goals are very strong, which can be seen in the existing strategies. Denmark's strategy shows a similar commitment to sustainability, providing a level playing field for people and fighting to help the poorest in society.

In addition to all these emphatic factors, we cannot ignore a strong contrast. Member States' ranking in composite indicators describing sustainable development is very appealing, but on a something-for-something basis, these countries leave a much larger footprint on the planet in other indicators (e.g., ecological footprint), contributing more to global sustainability problems. In addition to technological development, the top-ranked countries need more water and land to sustain themselves and absorb waste. We expect to see this in the 2019 WWF study on the per capita ecological footprint of EU Member States, which shows a contrast between sustainability as measured by the composite indicator and the ecological footprint (WWF, 2019). Overall, it can be concluded that the composite indicator of sustainable development by dimension, as well as the aggregated CSDGI index, is able to capture the current status of sustainable development in the EU Member States based on the methodology developed.

DISCUSSION

The author's research aims to measure sustainable development at EU level. In this context, the author has proved her research hypotheses by means of various mathematical-statistical and econometric methods. These methods have been widely used in research in the field, and in the future, it will be easier to draw conclusions on progress towards sustainable development goals. The widespread use of factor analysis provides an excellent opportunity to reduce a diverse database. The goodness of the method is also very well illustrated in the present study, i.e. the indicators for the 17 SDGs have been reduced significantly. The set of indicators has been reduced by between 46.7% and 63% over the five years studied so that the factors created retain the properties of the SDGs and can be used to simplify future research. The thesis related to the first hypothesis can be formulated as follows:

T1. A reduced set of indicators based on SDGs provides a simpler description of the state of the environment, employment and health care, economic and health status, not least resource productivity. In terms of the information content, the 2030 Agenda set of sustainable development indicators faithfully reflects the properties and content of the complex indicator system in a similar way to the original.

The relationship between the factors developed in the FA was examined to see if a correlation could be found between them and the GDP, HDI indicators. To prove this, correlation analysis was used by the author of this paper. A statistically significant correlation between the 17 SDG factors and GDP was found for four years, as there were more cases with a good correlation coefficient than those with a bad one. However, the assumption is overturned for one year. This relationship is much more favourable with the HDI indicator, as there are more statistically significant relationships in all years examined. The HDI indicator has a much stronger correlation coefficient with the 2030 Agenda factors, with 36/16 in 2014, 38/20 in 2015, 35/20 in 2016, 36/26 in 2017 and 37/29 in 2017 with a corresponding correlation coefficient. The thesis based on these is the following:

T2. There is a significant correlation between the factors created from the 17 SDGs and the GDP indicator ($r = -0.83 - -0.38$; $r = 0.38 - 0.92$), which is also found for the HDI ($r = -0.9 - -0.38$; $r = 0.39 - 0.87$). For GDP, the correlation is due to factors including energy, health expenditure, factor income in agriculture, justice, Official Development Assistance (ODA), and, last but not least, R&D. The HDI indicator for human development shows a stronger relationship with employment, education and R&D investment, i.e. social factors, while the relationship is weaker for agricultural R&D.

An examination of the international literature reveals a number of studies that use composite indicators to measure the impact of processes in a selected area, even progress, as in this hypothesis of the author's present study. In order to prove the hypothesis of composite indicators, the author used a scale-alignment transformation to create the indicator.

Accordingly, the author has created the $CSDGI_{Econ, Env, Soc}$ indicators related to the dimensions of sustainable development for the five years under study, as well as the CSDGI composite indicator. The related thesis is as follows:

T3. The composite indicators ($CSDGI_{Econ, Env, Soc}$), developed from the SDGs, show the commitment of the 28 EU Member States to sustainable development, both in part – as dimensions – and together (CSDGI). For the studied five years, Denmark, Sweden, Finland, the Netherlands, Austria, and Germany have topped the rankings, which is also explained by the size of their ecological footprint and the targets set in their sustainable development strategies.

By comparing the results presented in this study with other studies measuring sustainable development, it can be concluded that the topic has not been studied in this form, with exactly these methods and in this composition by other researchers. Nevertheless, a number of researchers, such as Filzmoser et al. (2009), Mainali et al. (2015), and Nardo et al. (2005), have used factor analysis in their research to methodologically demonstrate the extent to which the method is suitable for data reduction. In the case of correlation analysis, the results of the research are not at all comparable with the work of other authors, since no one carried out an analysis of the factors created in this combination. Thus, the results can be considered as completely new.

There are many examples of composite indicators in the literature, but they are not typically based on Eurostat's SDG database. Bolcárová & Kološta (2015) created an aggregated indicator (aSDI – Aggregated Sustainable Development Index) from the old database of sustainable development indicators called SDIs, where the main method was PCA. In contrast, Cîrstea et al. (2018) considered the sustainability of renewable energy sources as a sub-area of sustainable development in their research where they developed az index, called RESI (Renewable Energy Sustainability Index). Overall, the research cannot be compared with the findings of other researchers in terms of the methods used and the database.

Based on the theses presented here, the first and third hypotheses proved to be true, while for the second hypothesis it is only half true for GDP, while for HDI it is fully true. Thus, overall, the selected methods can be properly implemented on the database and are well suited for characterization.

CONCLUSION

The history of sustainable development has really changed since the 1960s. Beginning with the recognition of the problem in Rachel Carson's Silent Spring and followed by various conferences and conventions, there has been a growing emphasis on identifying problems and possible solutions, not least measurability. The present research has also attempted to measure and present progress towards the SDGs in the EU Member States for the period 2014-2018. The 2030 Agenda is difficult to measure through indicators due to its diverse characteristics and can only be measured in a cautious way.

By proving the hypotheses, the author has demonstrated that the set of indicators can be reduced by FA (more precisely, by creating factors) and that the factors created from it can be further explored to achieve sustainable development. A significant statistical relationship has been demonstrated by correlation analysis, which is due to the fact that the indicators in the factors have retained their properties during the reduction process. The Composite Sustainable Development Goal Indicator (CSDGI) allows Member States to be assessed using a single composite score. One limitation of the study is that it only covered five years between 2014 and 2018. Nevertheless, measuring sustainable development will be much easier in the future based on the existing methodology. The second limitation is that Eurostat is constantly reviewing the database, and the presentation of indicators according to the SDGs will change and cannot be ignored. Some indicators may no longer be part of the SDGs. In conclusion, there are significant differences between global issues, sustainable development strategies the relevance of the issue itself, and the relevance of each goal, but they are quantifiable.

Acknowledgement

"This work has been implemented by the TKP2021-NKTA-21 project with the support provided by the Ministry of Culture and Innovation of Hungary from the National Research, Development and Innovation Fund, financed under the 2021 Thematic Excellence Programme funding scheme."

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