Country-Level Sustainability Indicators in Central and Eastern Europe: Integrating UN SDGs and Ecological Footprint to Identify Meaningful Clusters and Assess Regional Performance

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The development of sustainability indicators at the national level emerged due to the limitations of using GDP as a measure of well-being, sustainability, and resilience. Over time, various indicators have been formulated, with a shift in focus from solely economic growth to a more encompassing perspective. The objective of this study was to integrate two methodologies, namely UN Sustainable Development Goals Index (SDGI), and the Global Footprint Network's Ecological Footprint (EF), in order to identify meaningful clusters of countries based on both measures. Our secondary aim was to reveal the similarities and differences between countries of the Central and Eastern European region. The clustering outcomes revealed that a three-cluster solution can be considered satisfactory. The results confirm the absence of decoupling at a macro level and provide evidence that the SDGs adequately address the intricate nature of sustainability. As for the countries in Central and Eastern Europe we found that this country group's SDGs is above average, but this group of countries is not homogeneous. Significant disparities are apparent in the variations observed in the SDG 9 scores.

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1 Introduction

The evolution of country-level sustainability indicators was necessitated by the flaws and limitations of GDP as an indicator of well-being, sustainability, and resilience (Stiglitz et al. 2009). Several different indicators have been developed over time to measure sustainability at the national level. The creation of these indicators has allowed better measuring of the well-being, social welfare, and ecological sustainability of societies. As sustainability goals continue to evolve, sustainability indicators will continue to develop, and new ones will be created to address emerging challenges. However, each country-level sustainability indicator has been subject to significant criticism based on their measurement methods and limitations.

We can conclude that while these alternative indicators are valuable in measuring progress towards sustainability goals, no indicator addresses all aspects of sustainability comprehensively and appropriately. These limitations and potential weaknesses highlight the need for a holistic approach in sustainable policy-making that acknowledges the complexity of sustainability, embraces new data sources and methods, and integrates the diverse perspectives of stakeholders across sectors and disciplines.

Our research aims to combine two of the aforementioned methodologies, the Ecological Footprint (EF) and the SDG Index (SDGI). While the main critique of EF from a wider sustainability perspective is its sole focus on environmental aspects, the SDGI has been often criticised due to its weak integration of these aspects. The goal of the research was to integrate the advantages of these methods, and to find meaningful clusters of countries according to the two measures.

2 Theoretical background

The SDG Index is an assessment of each country's overall performance on the UN 17 Sustainable Development Goals (SDGs), giving equal weight to each goal (Sachs et al., 2023). The score indicates a country's position between the worst possible outcome (a score of 0) and the target (a score of 100). The dashboard and trend arrows help identify priorities for further actions and indicate whether countries are on or off track to achieve their goals and targets by 2030, based on the latest trend data. The 2023 SDG Index edition includes 97 global indicators. Two-thirds of the data come from official statistics (typically from United Nations custodian agencies), with one-third from non-traditional statistics, including research centres, universities, and non-governmental organizations.

Since 2015, the SDG Index and Dashboards have been peer-reviewed, and the global edition was statistically audited by the European Commission in 2019 (Schmidt-Traub et al. 2017; Papadimitriou et al., 2019). The SDG index scores serve as a valuable tool for monitoring a country's progress in achieving sustainable development. Analysing these data can help identify both areas of success and those that may require more attention or targeted interventions.

Ecological footprint is an indicator developed by the Global Footprint Network (GFN) to measure a country's ecological impact. It measures the amount of land required to support a country's consumption and waste disposal patterns (Wackernagel & Rees, 1995). The ecological footprint includes land used for food, timber, energy, and infrastructure. It also includes land required to absorb carbon emissions and other pollutants. It is a useful indicator of sustainability because it reflects how human activities impact the environment and how sustainable the current consumption patterns are. Additionally, the ecological footprint has been widely adopted by international organizations, such as the United Nations, as a measure of sustainability. The ecological footprint is versatile and provides many possibilities for analysis (Kocsis, 2014).

The ecological footprint for each country is expressed in terms of global hectares (gha) per person. The global average ecological footprint for the last available year (2018) is 2.8 gha per person, while biocapacity (the number of hectares available to each person) is 1.6 gha per person (GFN 2018). This means that the resources of the Earth are overused by 75%.

Szigeti and others investigated the decoupling state of GDP and ecological footprint of 131 countries. Among them, 40 countries experienced strong decoupling (absolute reduction in resource use), 77 countries experienced weak decoupling (relative decrease in resource use), and only 14 countries did not observe decoupling (relative increase in resource use) (Szigeti et al. 2017). Wang and others (2022) investigated the decoupling trend in 166 countries from 1990 and 2015, and concluded that decoupling showed an improvement trend. Among them, upper-middle income countries improved the earliest (2003), and low-income countries improved the latest (2009). They also observed that the evidence of the inverted U-shaped nexus between economic growth and ecological footprint shows the validity of the Ecological Kuznets Curve globally, however, this nexus is not significant in low-income countries. Renewable energy consumption, population aging, financial development and trade openness all contribute to the reduction of the ecological footprint (Wang et al. 2022).

Based on a model of historical data and modelled projections Ward and others (2016) demonstrate that growth in GDP ultimately cannot be decoupled from growth in material and energy use, and argue that GDP is a poor proxy for societal wellbeing. Proponents of steady-state economy and degrowth therefore emphasise the goal of de-growing the economy within ecologically sustainable limits while at the same time increasing human wellbeing but defined in non-GDP terms (Latouche 2009; Daly 2014; Washington and Twomey 2016; Kallis et al. 2018). According to this view, the point of degrowth is not only downscaling in quantitative terms, but also a change in the objectives of the economy.

3 Methodology

For our study we used two databases, one is the National Footprint and Biocapacity Accounts (NFA) database and the other is the SDI Report (SDR) database.

NFA measure countries' ecological resource use and resource regeneration capacity. The accounts are based on around 15,000 data points per country per year, providing the baseline data for ecological footprint (EF) analysis for 184 countries in the latest data table for 2018, edited in 2022. Commissioned by the Footprint Data Foundation (FoDaDo), the National Footprint and Biocapacity Accounts 2022 Edition is produced by the Ecological Footprint Initiative of York University in collaboration with GFN (Lin et al., 2018). The 2022 SDG Index database includes data from previous years in addition to the most recent data, of which 2018 is used for comparability with the NFA. Data for 2018 were available for 177 countries

(Sachs et al., 2022). By merging the two databases, we found 159 countries that are included in both databases (hereinafter referred to as: "our database").

Central and Eastern European Countries (CEECs) is an OECD term for the group of countries comprising Albania, Bulgaria, Croatia, the Czech Republic, Hungary, Poland, Romania, the Slovak Republic, Slovenia, and the three Baltic States: Estonia, Latvia and Lithuania (OECD 2001).

A key moment in clustering is how we measure the distances between countries. One possible subdivision of clustering procedures is the so-called hierarchical and non-hierarchical classifications. An important difference between the two methods is that the number of clusters in hierarchical methods is not predetermined, whereas in non-hierarchical classifications, cases are classified into a predefined number of clusters. To group the countries, cluster analysis was carried out using the hierarchical clustering method. The Nearest Neighbour method was used to filter outliers. The Ward method was used to determine the clusters. Clustering was performed using the SPSS software package.

Pearson's correlation coefficient was calculated between the 17 indicators and EF. The baseline calculations (hierarchical clustering and correlation matrix) resulted in further calculations with data for 157 countries and 18 indicators. We subtracted the EF data from 100 (which is the maximum value of the SDG Indices). Thus, a higher value indicates a more favourable, i.e. smaller ecological footprint. The table used for the calculation is presented (see Table 1). Our study investigated the positioning of CEE countries within the clusters.

Following the completion of our calculations, we obtained access to the 2019 ecological footprint data, prompting us to reassess our findings using this updated information. Through our analysis, we identified 155 countries with data available for comparison. Additionally, in order to better understand the significance of the ecological footprint, we conducted a supplementary analysis excluding this factor.

4 Results

The SDG Index has an average of 66. Universally replicable well-being requires an average ecological footprint smaller than the world average biocapacity. At current human population levels, there are 1.6 global hectares of biologically productive land on Earth per person. Given the growing population and the recognition of the need for biocapacity of wild species, the average global ecological footprint per capita needs to be reduced significantly below this threshold.

Based on the results of the correlation matrix there is no strong relationship between variables, so all variables can be left out of the analysis without significant bias.

Table 1: Cluster centres (2018)

SDG Scores	Clusters (Ward)		
	(2) Emerging countries	(1) Remainder of the Globe	(3) Developed countries
Goal 1	29.67	85.44	97.90
Goal 2	51.13	59.53	67.10
Goal 3	40.63	72.62	89.67
Goal 4	42.09	81.10	95.40
Goal 5	47.15	61.19	71.94
Goal 6	49.40	69.69	80.07
Goal 7	43.00	72.83	74.47
Goal 8	58.43	67.06	78.85
Goal 9	14.54	37.69	78.77
Goal 10	47.63	53.02	84.10
Goal 11	49.26	75.23	83.68
Goal 12	95.97	88.07	67.69
Goal 13	97.62	88.12	52.24
Goal 14	68.17	63.24	61.94
Goal 15	65.75	61.15	72.47
Goal 16	51.33	65.96	80.86
Goal 17	50.15	62.37	61.73
ef trans	98.74	97.30	94.03
average	55.59	70.09	77.38

The result of the clustering shows that the 3-cluster solution can be considered as acceptable. The cluster centres are shown in Table 1. A Nearest Neighbour clustering method resulted in the exclusion of two countries from the analysis, Bolivia and Haiti.

- Cluster 3: 'Developed countries' countries perform exceptionally well across SDG1, SDG3 and SDG4. In addition to EU member countries, this includes most of CEE countries: Croatia, the Czech Republic, Hungary, Poland, Slovak Republic, Slovenia, and the three Baltic States: Estonia, Latvia and Lithuania among others.
- Cluster 1: 'Remainder of the Globe' lags behind Cluster 3 by an average of 10% of the overall score. A very significant lag is observed for SDG 9 (above 50%), while SDG 12 and SDG 13 have significantly higher scores (around 30%). Among the CEECs, Albania, Bulgaria and Romania are in the 'Reminder of the Globe' cluster.
- In Cluster 2, referred as 'Emerging countries', there is an ongoing downward trend in the average score when compared to Cluster 1. Notably, there is a substantial decrease in scores for SDG1 and SDG 9, whereas scores for SDG12 and SDG13 exhibit continuous improvement.

Table 2: Selected data from the CEE countries

Country	Ecological Footprint [gha per capita]	Biocapacity [gha per capita]	Deficit	SDG Index Score	Goal 9 Score
Albania	**1,9**	**1,0**	**-0,9**	**72,2**	**29,3**
Bulgaria	**3,6**	**3,3**	**-0,3**	**73,3**	**54,3**
Lithuania	6,0	4,7	-1,3	74,6	65,5
Romania	**3,6**	**3,2**	**-0,4**	**77,1**	**55,8**
Slovakia	4,7	2,8	-1,9	77,8	65,7
Croatia	3,9	2,8	-1,0	78,1	65,9
Hungary	3,9	2,6	-1,3	78,3	69,3
Slovenia	5,4	2,2	-3,2	79,6	72,8
Latvia	6,4	8,2	1,8	79,6	66,5
Czech Republic	5,7	2,3	-3,4	79,9	78,2
Estonia	8,0	9,3	1,3	79,9	77,5
Poland	4,8	1,9	-2,9	80,2	73,2

The countries in Table 2 are arranged in ascending order based on their SDG Index scores. It is important to note that all countries have scores above the average SDGI score. The three Goals that display a decline in scores (SDG12, SDG13, SDG14) are primarily associated with the environmental pillar of sustainability. This suggests that when societies make progress in terms of their socio-economic conditions, they do so at the expense of the environment, thereby indicating the absence of decoupling in this particular field. Re-running the calculation using data from the year 2019 yields a result that closely mirrors the original findings, with negligible variations observed in the decimal points. Even when the ecological footprint is omitted from the clustering analysis, the resultant outcomes remain consistent with the initial observations. This strongly indicates that countries categorized within clusters exhibiting higher scores are failing to fulfill the anticipated objectives within the environmental domain.

This statement confirms and reinforces two significant assumptions: first, that there is no decoupling phenomenon observed at the macro level, and second, that the SDGs adequately incorporate the essential environmental attributes necessary for comprehensively addressing the complex issue of sustainability.

5 Conclusions

Previous research has shown that good economic and social performance in developed countries comes at an environmental price. It has also been found that living with a low ecological footprint in countries with a low environmental impact is associated with severe socio-economic disadvantages. The 'Remainder of the Globe', while lagging slightly behind developed countries in terms of economic and social goals, performs significantly better in terms of environmental indicators. Addressing SDG9 can be a strategic issue of how to build resilient infrastructure, promote inclusive and sustainable industrialisation, and stimulate innovation without significant trade-offs in meeting environmental goals The contrast in SDG 9 values among CEE countries is notably pronounced compared to the overall SDG Index, where the greatest difference between the highest and lowest scores is merely 10%. In contrast, the variation in SDG9 values is significantly amplified, reaching two and a half times the magnitude of this difference, as illustrated in Table 2.

We believe the evidence supports the following conclusions:

- Despite the potential benefits of integrating ecological footprint indicators into the UN sustainability index, the combination of these two indices to address their shortcomings is considered superfluous in terms of methodological innovation.

- Data reliability is serious concern, and it has implications for monitoring progress and informing policy decisions.
- The environmental component of the SDGI is sufficient for the purposes of comparison.
- There is a significant trade-off involving in decoupling, as it entails a shift away from advanced development levels and raise cultural and consciousness-related issues, as well as potential risks in the form of perceived political self-harm.

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