Indicator-based assessment of local and regional progress toward the Sustainable Development Goals (SDGs): An integrated approach from Romania

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Abstract
In order to measure progress in achieving the Sustainable Development Goals (SDGs) by 2030, 169 targets have been approved globally. Even though interest in implementing these goals is high, many states have not yet established a set of sub-national indicators to measure the implementation of the SDGs and have not completed their own assessment of progress in achieving these global goals. This study aims to measure the progress toward achieving the SDG at local and regional level in Romania by calculating the SDG Index. For the calculation of the SDG Index at sub-national level, we propose an integrated approach based on 90 indicators, stored and processed in a PostgreSQL object-relational database. The results show the concentration of the highest performances of sustainable development in some specific geographical areas. The rural areas and the extended peripheral regions in the eastern and southern part of the country are the poorest performers.

KEYWORDS
integrated approach, local and regional sustainable development, SDG Index, sustainable development indicators

1 | INTRODUCTION

At the United Nations Sustainable Development Summit in September 2015, the 193 member states of the United Nations adopted the 2030 Agenda for Sustainable Development designed to eradicate poverty, fight inequality and injustice, and protect the planet. The 2030 Agenda includes a set of 17 Sustainable Development Goals (SDGs) and 169 targets for assessing and monitoring sustainable development by 2030.

The Sustainable Development Solutions Network (SDSN) and the Bertelsmann Stiftung have released annually since 2016 an SDG Index and a dashboards to assess countries' performance on the SDGs (Sachs, Schmidt-Traub, Kroll, Durand-Delacre, & Teksoz, 2016; Schmidt-Traub, Kroll, Teksoz, Durand-Delacre, & Sachs, 2017). Based on the available international indicators, the SDSN and the Bertelsmann Stiftung have calculated a composite index for each of the 17 SDGs, which they subsequently aggregated into an overall SDG composite index using equal weights. Similar concerns were expressed by Xu et al. (2020) who conducted a spatiotemporal analysis of progress toward the SDGs at the national and subnational (provincial) levels in China for the period 2000–2015 using 119 SDG indicators. At national level, the SDG Spanish Cities Index report was launched in 2018 (Sánchez de Madariaga, García López, & Sisto, 2018). It provides an image of the level of sustainable development of 100 cities with more than 80,000 inhabitants.
from Spain, based on 85 SDG indicators. Based on 39 SDG indicators, Cavalli and Farnia (2018) have developed the Italy SDG Cities Index for examining the SDG implementation in 101 municipalities from Italy. The SDSN in partnership with the Brabant Center for Sustainable Development (Telos, Tilburg University) have released in 2019 the first SDG Index and Dashboards Report for European Cities. The report assesses and compares the performance of 45 capital cities and a selection of large metropolitan areas in the EU on the 17 SDGs using 59 indicators. The capital cities of the Nordic countries registered the highest values: Oslo (74.8), Stockholm (74.2), Helsinki (71.3), and Copenhagen (68.7) are closest to the SDG targets, while the capital cities from Southern Europe were the worst performers, among them the Romanian capital Bucharest (54.4 SDG Index score) (Lafortune et al., 2019).

Off course, the list of studies working on the operationalization of SDGs is long (see also Allen, Reid, Thwaites, Glover, & Kestin, 2020; Bocárová & Kolostá, 2015; Campagnolo et al., 2018; Dalampira & Nastis, 2019; Hametner & Kostetckaia, 2020; Nhemachena et al., 2018; Török & Benedek, 2018). For an effective implementation and assessment of the SDGs, we cannot ignore the evaluation of the rural areas, and therefore we argue for an integrated territorial approach of measuring the SDGs. This approach offers three novelties: the generation of a territorial database on local level, which includes both rural and urban areas; the large employment of earth observations methods in the measurement of the SDG indicators; and the development of a new data model for the measurement of the SDG Index.

More explicitly, in order to measure the progress of each commune, city, and county (subnational, NUTS 3-level statistical units) in achieving the SDGs, we proposed to calculate the SDG Index at local and county level. The SDG Index is a composite index that sums up individual scores calculated for each of the 17 SDGs. In calculating the individual scores, we developed a set of monitoring indicators that were subsequently aggregated at the level of each SDG, thus obtaining 17 specific composite indices for measuring the SDGs. These indices allow the establishment of the level and stage reached by each local government and county for each specific objective of sustainable development. The overall SDG composite index resulting from the sum of specific composite indices assesses the general performance of each commune, city, and county in Romania in achieving all 17 SDG.

We outline that the present study is an attempt to quantify the performance of each LAU (Local Administrative Units) on the SDGs, contributing in this way to calls for more progress in the operationalization of SDGs and in the evaluation of indicators’ relevance (Hák, Janousková, & Moldan, 2016; Halisçelik & Soytas, 2018; Holden, Linnerud, & Banister, 2017). It will provide a policy-relevant assessment tool for the LAUs in establishing their position within each SDG, which in turn will help them to set up empirically sound and politically relevant Local Development Strategies. Moreover, understanding the differences in sustainable development across multiple scales and resources will enhance the ability of central authorities to balance sustainable development between national and various subnational levels.

2 | DATA AND METHODS

The calculation of the SDG index at local (LAU, 3181 local administrative units: communes and cities) and county (NUTS-3, 41 counties and the Municipality of Bucharest) level in Romania involved several work steps.

2.1 | Data collection

As mentioned in the Introduction, one important original contribution of the article is the mix of data resources employed in the generation of 90 indicators and in the consequent measurement of the SDGs, and the outstanding role of Earth Observation methods, which are employed, to our knowledge, for the first time at this scale in SDG measurement oriented studies.

The first data resource used is represented by the classical sources: the National Institute of Statistics (NIS), the 2011 Population and Dwellings Census (RPL), and the Territorial Observatory (TO) (Table 1).

The second data source was from Earth Observation, which was the basis for calculating seven SDG indicators at local and county level. The use of earth observations methods in the measurement of the SDG indicators provides an original contribution of the study by updating the territorial database on local level in the absence of current statistical recordings. More exactly, the Copernicus Land Monitoring Services offer a series of very useful information for the objectives of SDG 2, SDG11, SDG 13, SDG14, and SDG15. From this database, we used the Corine Land Cover (CLC) and High Resolution Layers (HRL)—imperviousness datasets. The European Copernicus programme coordinated by the European Environment Agency (EEA) provides information regarding land cover and land use (Corine Land Cover) and high-resolution imperviousness datasets at European level (HRL imperviousness) based on satellite images. Corine Land Cover data are available for the years 1990, 2000, 2006, 2012, and 2018 and include the following main classes: (a) artificial surfaces, (b) agricultural areas, (c) forests and semi natural areas, (d) wetlands, and (e) water bodies. From the CLC data, the information related to 2012 and 2018 was used; these being derived from the satellite images IRS P6 LISS III and RapidEye (CLC, 2012) in (EEA, 2020a), respectively, Sentinel-2 and Landsat-8 (CLC2018) (EEA, 2020a). “HRL imperviousness” data are available for the years 2006, 2009, 2012, and 2015 and are derived from the IRS-P6/Resourcesat-2 LISS-III, SPOT 5, and Landsat 8 satellite images (EEA HRL, 2020b). The information extracted from these databases was processed using GIS tools and subsequently aggregated at the level of Romanian municipalities,
| SDG | Indicator                                                                 | Latest Available Year | Source         | Normalisation (0-10) |
|-----|---------------------------------------------------------------------------|-----------------------|----------------|----------------------|
| 1   | Revenues per capita (RON/person)                                          | 2018                  | MRDPA, 2018    | x                    |
|     | Public expenses per capita (RON/person)                                   | 2018                  | MRDPA, 2018    | x                    |
|     | Social public expenses (RON/person)                                       | 2018                  | MRDPA, 2018    | x                    |
|     | Youth not in employment, education or training (NEET) %                   | 2011                  | RPL, 2011      | x                    |
| 2   | Agricultural area (% of total area)                                       | 2018                  | EEA, 2020a     | x                    |
| 3   | Infant mortality rate (per 1000 people)                                  | 2018                  | NIS, 2020      | x                    |
|     | Medical-sanitary staff density (per 1000 people)                         | 2018                  | NIS, 2020      | x                    |
|     | Physician density (per 1000 people)                                      | 2018                  | NIS, 2020      | x                    |
|     | Share of elderly population (%)                                          | 2020                  | NIS, 2020      | x                    |
|     | Share of young population (%)                                            | 2020                  | NIS, 2020      | x                    |
|     | Family medical practices (per 1000 people)                               | 2017                  | TO, 2020       | x                    |
|     | Number of the beds from sanitary units (per 1000 people)                 | 2018                  | NIS, 2020      | x                    |
|     | Civil economically active population (%)                                 | 2011                  | RPL, 2011      | x                    |
|     | Mortality rate (per 1000 people)                                         | 2018                  | NIS, 2020      | x                    |
|     | Live-birth rate (per 1000 people)                                        | 2018                  | NIS, 2020      | x                    |
|     | Natural increase of the population (per 1000 people)                     | 2018                  | NIS, 2020      | x                    |
|     | Migratory increase of the population (per 1000 people)                    | 2018                  | NIS, 2020      | x                    |
|     | Public expenses on health (RON / person)                                  | 2018                  | MRDPA, 2018    | x                    |
| 4   | Share of population with higher education (%)                             | 2011                  | TO, 2020       | x                    |
|     | Illiterate population (%)                                                 | 2011                  | TO, 2020       | x                    |
|     | Population aged 25 and above with higher educ (%)                         | 2011                  | RPL, 2011      | x                    |
|     | Public expenses on education (RON / person)                               | 2018                  | MRDPA, 2018    | x                    |
|     | Share of population without education (%)                                 | 2011                  | TO, 2020       | x                    |
|     | Population 25 and above with upper-, post-secondary, non-tertiary educ (%) | 2011                  | RPL, 2011      | x                    |
|     | Education units (per 1000 people)                                        | 2018                  | NIS, 2020      | x                    |
| 5   | Female labor force participation rate (%)                                 | 2011                  | RPL, 2011      | x                    |
|     | Female average years of schooling of population aged 25 and above (%)     | 2011                  | RPL, 2011      | x                    |
|     | Share of female unemployed (%)                                           | 2019                  | NIS, 2020      | x                    |
| 6   | Sewer network density (km/km2)                                            | 2018                  | NIS, 2020      | x                    |
|     | Access to current water (% of total dwellings)                           | 2011                  | RPL, 2011      | x                    |
|     | Access to hot water (% of total dwellings)                               | 2011                  | RPL, 2011      | x                    |
| 7   | Access to central heating (% of total dwellings)                         | 2011                  | RPL, 2011      | x                    |
|     | Access to electricity (% of total dwellings)                             | 2011                  | RPL, 2011      | x                    |
| 8   | Automated teller machines and banks (per 1000 people)                    | 2020                  | OSM, 2020      | x                    |
|     | Employment to population ratio (%)                                        | 2018                  | NIS, 2020      | x                    |
|     | Unemployment rate (%)                                                     | 2019                  | NIS, 2020      | x                    |
|     | Establishments of touristic reception (per 1000 people)                   | 2018                  | TO, 2020       | x                    |
|     | Degree of use of touristic accommodation capacity                         | 2018                  | TO, 2020       | x                    |
| 9   | Natural gas network density (km/km2)                                     | 2018                  | NIS, 2020      | x                    |
|     | Water network density (km/km2)                                            | 2018                  | NIS, 2020      | x                    |
|     | Road density (km/km2)                                                     | 2018                  | TO, 2020       | x                    |
|     | National road accessibility (km)                                          | 2018                  | TO, 2020       | x                    |
|     | County road accessibility (km)                                            | 2018                  | TO, 2020       | x                    |
|     | School teachers (per 30 pupils)                                          | 2018                  | NIS, 2020      | x                    |
|     | Railway density (km/km2)                                                  | 2018                  | TO, 2020       | x                    |
|     | Public expenses on transport (RON / person)                              | 2018                  | MRDPA, 2018    | x                    |
| SDG | Indicator                                                                 | Latest Available Year | Source                | Normalisation (0-10) |
|-----|---------------------------------------------------------------------------|-----------------------|-----------------------|----------------------|
| 10  | Local Human Development Index                                             | 2011                  | Sandu, 2011           | x                    |
| 11  | Finished dwellings (per 10000 people)                                    | 2018                  | TO, 2020              | x                    |
|     | Population density (people per km²)                                      | 2018                  | TO, 2020              | x                    |
|     | Population growth rate (%)                                               | 2017-2018             | TO, 2020              | x                    |
|     | Access to bath (% of total dwellings)                                    | 2011                  | TO, 2020              | x                    |
|     | Access to water-closet (% of total dwellings)                            | 2011                  | TO, 2020              | x                    |
|     | Land Use Efficiency                                                      | 2006-2015             | EEA, 2020b            | x                    |
|     | Living floor (m² per person)                                             | 2018                  | NIS, 2020             | x                    |
|     | Traffic deaths rate (per 1000 people)                                    | 2019                  | GIRPTD, 2019          | x                    |
|     | Serious traffic accidents rate (per 1000 people)                         | 2019                  | GIRPTD, 2019          | x                    |
|     | Slight traffic accidents rate (per 1000 people)                          | 2019                  | GIRPTD, 2019          | x                    |
|     | Traffic accidents (per 1000 people)                                      | 2019                  | GIRPTD, 2019          | x                    |
|     | Housing density (number of people per room)                              | 2011                  | TO, 2020              | x                    |
|     | Average number of people per household (number)                          | 2011                  | TO, 2020              | x                    |
|     | Building permits (per 1000 people)                                       | 2018                  | NIS, 2020             | x                    |
|     | Public expenses on housing, services and public development (RON/capita) | 2018                  | MRDPA, 2018           | x                    |
|     | Public expenses on culture (RON/capita)                                  | 2018                  | MRDPA, 2018           | x                    |
| 12  | Access to wastewater network/septic tank (% of dwellings)                | 2011                  | RPL, 2011             | x                    |
| 13  | Forest areas (% of total area)                                           | 2018                  | EEA, 2020a            | x                    |
|     | Cooling index (CI)- days with minimum temperatures below -15 °C.         | 1961-2013             | Dumitrescu, 2015      | x                    |
|     | Temperature humidity index (THI)                                         | 1961-2013             | Dumitrescu, 2015      | x                    |
|     | Growth rate of built-up areas (%)                                        | 2006-2015             | EEA, 2020b            | x                    |
|     | Public expenses on environmental protection (RON/capita)                 | 2018                  | MRDPA, 2018           | x                    |
|     | Average annual concentration of Nitrogen Oxides (NO2)                    | 2019                  | Sentinel 5P           | x                    |
| 14  | Water bodies (% of total area)                                           | 2018                  | EEA, 2020a            | x                    |
| 15  | Natural monument (% of total area)                                       | 2018                  | TO, 2020              | x                    |
|     | National parks (% of total area)                                         | 2018                  | TO, 2020              | x                    |
|     | Natural parks (% of total area)                                          | 2018                  | TO, 2020              | x                    |
|     | Biosphere reserves (% of total area)                                     | 2018                  | TO, 2020              | x                    |
|     | Natural reservations (% of total area)                                   | 2018                  | TO, 2020              | x                    |
|     | Strictly protected reservations (% of total)                             | 2018                  | TO, 2020              | x                    |
|     | Natura SCI sites(% of total area)                                        | 2018                  | TO, 2020              | x                    |
|     | Natura 2000 sites(% of total)                                            | 2018                  | TO, 2020              | x                    |
|     | Ramsar sites (% of total)                                                | 2018                  | TO, 2020              | x                    |
|     | SPA protected areas (% of total area)                                    | 2018                  | TO, 2020              | x                    |
|     | Surface of protected areas (% of total area)                             | 2018                  | TO, 2020              | x                    |
|     | Change in forest area (%)                                                | 2012-2018             | EEA, 2020a            | x                    |
| 16  | Public expenses on defense (RON/capita)                                  | 2018                  | MRDPA, 2018           | x                    |
|     | Crime coefficient (Index)                                                | 2018                  | GIRPTD, 2019          | x                    |
|     | Proportion of the population using internet (%)                          | 2011                  | RPL, 2011             | x                    |
|     | Number of libraries (per 1000 people)                                    | 2018                  | NIS, 2020             | x                    |
|     | Number of museums (per 1000 people)                                     | 2017                  | NIS, 2020             | x                    |
| 17  | EU funds revenues (RON/capita)                                           | 2018                  | MRDPA, 2018           | x                    |
|     | National programs funds revenues (RON/capita)                            | 2015                  | MRDPA, 2018           | x                    |

1Abbreviations: x - min-max normalization method; x- max-min normalization method
cities, and counties. Based on Sentinel 5-P satellite images, the annual mean concentration of nitrogen dioxide (NO₂) for 2019 was extracted using the Google Earth Engine tool. Thus, we managed to develop our own set of indicators by processing the information obtained from satellite images.

The third data source is represented by two central government institutions: the Ministry of Regional Development and Public Administration (MRDPA) has provided data on public revenue and public expenses by category, while the General Inspectorate of Romanian Police, Traffic Department (GIRPTD) offered the data on road accidents and crime coefficient index. The crime coefficients index was calculated by processing the annual statistical data on the crimes reported at local and county level in Romania.

And finally, the last data category are represented by the so-called open sources: data on the number of Automated Teller Machines (ATM) and banks in Romania were extracted from the OpenStreetMap database, and ROCADA (ROmanian ClimAtic DAtaset) for the following climate indices: Cooling Index (CI) (days with minimum temperatures below −15°C) and Temperature Humidity Index (THI) using the netCDF Operator (NCDO) software under Linux for the period 1961–2013.

2.2 Database creation and data processing

Due to a large volume of data collected at the local and county level in Romania, in order to process these data and calculate indicators, it was necessary to create a database and find a tool which enabled us to quickly reprocess the data in case of input changes and corrections. The data were collected in multiple formats: ESRI Shapefile, CSV (comma-separated values), and JSON (JavaScript Object Notation), and in some situations, they were organized in sets for different years. In this case, a PostgreSQL object–relational database was created with the PostGIS extension, which allowed us to organize the data into schemas and tables and also to separate input data from results.

To create the results from the input data, we used the dbt tool (data build tool) which enabled us to transform, aggregate, and join datasets. With this tool, 568 models were created to process the data and 282 tests for validation and verification of the input data and results. Each model represents an .sql file containing a select statement for selecting, aggregating, and processing data which can be joined from multiple source tables (Figure 1). Tests are assertions that were made about the models in order to verify the correctness of the data and eliminate errors. These tests were running macroscripts to identify the null or zero columns and row counts to identify missing data. The models and the database thus created allowed us to quickly update the information and recalculate the SDG Index, respectively, to eliminate the errors that would occur in the manual processing of data.

Using the dbt tool and the SQL programming language, an individual model was created to calculate each indicator and workflow:

1. summation of values by administrative units: in this step, the data that were available on several categories or those available at locality level were summed, thus obtaining a value for each LAU and county;
2. joining data tables to LAUs and county limits;
3. calculation of indicators based on the data resulting from steps 1 and 2. An average of three–four models were used to calculate each indicator, such an example can be seen in Figure 1. This approach also allowed us to visualize the data processing flow and the connections between the data.

Based on the information extracted from the CLC dataset, the “forest area,” the “change in forest area,” the “agricultural area,” and the “water bodies area” indicators were calculated related to each LAU and county in Romania. Using the information extracted from the “HRL imperviousness” dataset for the years 2006 and 2015, the “growth rate of built-up area” and the “Land Use Efficiency” (LUE) were calculated. LUE indicator was used in order to measure the...
change rate of the built-up area per capita based on the following formula (Corbane, Politis, Siragusa, Kemper, & Pesaresi, 2017):

\[
LUE = \frac{Y_t - Y_{t+n}}{Y_t} \tag{1}
\]
\[
Y_t = BU_t / Pop_t \tag{2}
\]
\[
Y_{t+n} = BU_{t+n} / Pop_{t+n} \tag{3}
\]

where: LUE, land use efficiency indicator; BU_t, built-up area at the initial year (t); Pop_t, total population within the built-up area at the initial year (t); BU_{t+n}, built-up area at the final year (t+n); Pop_{t+n}, total population within the built-up area at the final year (t+n).

In calculating climate indices, we use the observed daily climatological spatial data (maximum air temperature, minimum air temperature, and relative humidity) interpolated on a grid at a spatial resolution of 0.1° (approximately 10 km). The data come from the ROCADA project and are available on the PANGAEA portal at doi.pangaea.de/10.1594/PANGAEA.833627 (Dumitrescu & Bîrsan, 2015).

The comparison was made with data from the regional model RACMO22E v.2 at a resolution of 0.11° for the rcp4.5 experiment (van Meijgaard et al., 2008). The analysis of the changes in the spatial distribution of the values of the bioclimatic indices was made over three periods: 2006–2030, 2031–2060, and 2061–2090 using the software netCDF Operator (NCO). The data are available on the Cordex—Coordinated Regional Climate Downscaling Experiment website (http://cordex.org/data-access/).

The National Meteorological Administration uses the Temperature–Humidity–THI indicator (Thom, 1958) to alert the population during summer. The threshold established by legal provisions is 80 units. If the threshold is exceeded, the National Heatwave Plan (Planul Național pentru Caniculă) is triggered.

THI combined temperature and humidity to measure the degree of discomfort an individual feels in hot weather. The original formula has been changed because it uses temperature expressed in degrees Fahrenheit. In our study, we used the following formula:

\[
THI = 0.81 \times T + 0.01 \times H + (0.99 \times T - 14.3) + 46.3 \tag{4}
\]

where: T, air temperature (°C), H, relative humidity (%).

The National Meteorological Administration uses, in operational activity during winter, the cooling indicator. Legal measures to combat the cold are taken if the temperature drops below −20°C or if the wind chill drops below −35°C. In our analysis, we only used the minimum temperatures because wind data are not available in the ROCADA project.

4. normalization of indicators: the values were normalized to become easily comparable on a scale of 1 to 10, using the min–max (x̄) and max–min (x̂) normalization method:

\[
\hat{x} = \left(\frac{x - \min(x)}{\max(x) - \min(x)}\right) \times 10 \tag{5}
\]

\[
\bar{x} = \left(\frac{\max(x) - x}{\max(x) - \min(x)}\right) \times 10 \tag{6}
\]

where x is the value of raw data; min (x) and max (x) determine the lower and upper bounds for worst and best performance, \(\hat{x}\) and \(\bar{x}\) is the normalized value after the rescaling process.

For most indicators, the min–max \(\hat{x}\) normalization method was applied, where 0 indicates the worst performance and 10 the highest performance. In the case of indicators such as “Youth not in employment, education or training (NEET),” “Unemployment rate,” “Traffic deaths rate” the max–min (\(\bar{x}\)) normalization method was applied, where 10 indicates the worst performance and 0 the highest performance (Table 1).

5. aggregating the data into a final table containing the 90 normalized indicators.

2.3 | Performing statistical tests

Prior to normalizing the values, a series of statistical tests were performed using the 90 calculated indicators to determine whether the variables taken into account in the SDG Index were normally distributed.

Assessing the normality of a dataset is an important step for many statistical analyses. Normality can be determined in three ways: graphically by applying the normal Q-Q plot, numerically by calculating the distribution as skewness and kurtosis, and finally by checking various statistical tests. In this paper, we have checked all three methods in order to be sure that all variables used for calculating the SDG corresponds to the methodological requirements. Variables that are not fulfilled this criteria were left out.

The normal Q-Q plot is a graphical tool, which helps to visualize that a dataset is normally distributed, thus, follows the diagonal line on the plot. Skewness and kurtosis levels of a dataset are usually part of the descriptive statistics output. The test of skewness measures the symmetry of a distribution, while the kurtosis focuses on the degree of peakedness or flatness highlighting the presence of outliers in a distribution. The kurtosis for a standard normal distribution is three (Field, 2013; Hair, Hult, Ringle, & Sarstedt, 2017; Miles & Shevlin, 2001). Skewness and Kurtosis are measured with the following equation:

\[
\text{Skewness} = \frac{\sum_{i=1}^{N} (X_i - \bar{X})^3}{(N-1)s^3}, \tag{7}
\]

\[
\text{Kurtosis} = \frac{\sum_{i=1}^{N} (X_i - \bar{X})^4}{(N-1)s^4} - 3, \tag{8}
\]

where \(\bar{X}\) is the mean, N is the number of data points, and s is the standard deviation.

Taken into consideration the sample size of an analysis, comparison studies have demonstrated that among various statistical tests,
Shapiro–Wilk test (Royston, 1993; Shapiro & Wilk, 1965) and Shapiro–Francia test (Royston, 1993; Shapiro & Francia, 1975) are the most powerful normality tests (Nornadiah & Yap, 2011; Yap & Sim, 2011). Both of them measure the hypothesis that the analyzed variables come from a normal distribution \((W\) and \(W'\) statistic). The results could be observed from the Sig. value \((\text{Prob} > z)\): if is greater than 0.05, the variable follows a normal distribution and the null hypothesis is not rejected; if is lower than 0.05, the variable is not normally distributed, thus the null hypothesis could be rejected. Shapiro–Wilk test requires a random sample of between 3 and 2000 (Royston, 1995), while Shapiro–Francia test is not sensitive in case of relatively large sample size \((\text{ranges from 5 to 5000})\) (Royston, 1993).

The Shapiro–Wilk test has the following equation:

\[
W = \frac{\left(\sum_{i=1}^{n} i a_i x(i)\right)^2}{\sum_{i=1}^{n} (x(i) - \bar{x})^2},
\]

where \(a_i\) is the vector of expected values of normal ordered statistics, and \(x_i\) is the ordered sample value. The Shapiro–Francia test has the same equation, using \(b\) instead of \(a\), representing the square of the Pearson correlation coefficient resulted from random sample values and the expected normal order statistics (Royston, 1993; Shapiro & Wilk, 1965; Shapiro & Francia, 1975).

As we could observe both the Shapiro–Wilk and Shapiro–Francia test presented in Appendix A reject the null hypothesis indicating that all used variables are not normally distributed, as \(p\)-values are less than .05. Lack of symmetry (skewness) and pointiness (kurtosis) also highlight the deviation from a normal distribution.

2.4 | Calculation of the SDG Index

The calculation of the SDG Index followed the methodology established by the United Nations (Schmidt-Traub et al., 2017), being an internationally agreed methodology.

In the first step, to determine the composite SDG Index, the components of each SDG were first weighed and aggregated. In order to eliminate subjective and flexible weightings and treating all SDGs equally, we resorted to giving equal weights to each SDG. Data aggregation involved: (a) aggregating normalized indicators into one specific composite index for each of the SD goals using arithmetic mean. Several studies have applied the arithmetic mean and the min–max methods to calculate the SDG Index (Nhemachena et al., 2018; Sachs et al., 2016, 2020; Schmidt-Traub et al., 2017; Tomalty et al., 2007; Xu et al., 2020) (b) aggregation of the specific SDG composite indices into the overall SDG composite index (Figure 2). The overall score of the LAU’s and county’s SDG Index was calculated based on the arithmetic mean using equal weights for each specific composite index. The SDG Index offers the possibility to compare scores at the level of communes, cities, and counties in Romania.

2.5 | Data limitations

The study presents some limitations. First, even though we use the most recent available data for each indicator, the old data from the last census (2011) and other data sets which are not up to date limit to give a precise reflection about the current situation of the analyzed territory. The second limitation of the analysis involves the use of a different number of indicators within the SD goals; in some cases, just
one indicator was used in the absence of data for lower administrative territorial levels. Finally, due to the normalization of the indicators and ranking them at local and county scale within Romania, the SDG Index scores cannot be compared with the indicators of other countries at similar LAU and county level.

3 | GENERATING THE SDG DASHBOARDS

In order to create the SDG Dashboards, we created a console application written in .NET Core which uses an HTML template as the dashboard design and the SDG calculated indices as input data. This software reads the 17 specific SDG composite indices and the overall SDG composite index classifies them into four classes (four colors) and writes them into the HTML template. The breakpoints for the four classes were defined in a configuration file, and their values were obtained based on the natural breaks (Jenks) classification method from ArcGIS software. The natural breaks classification is based on the Jenks Natural Breaks algorithm and creates classes by grouping similar values while maximizing the differences between these classes. Each class with its color represents the scale of the achieved performance, thus green, orange, yellow, and red colors in this order are representing the transition between the highest and the worst performance of sustainable development.

4 | RESULTS AND DISCUSSIONS

The resulting SDG Index at LAU and county level has standardized values ranging from 0 to 10, 10 representing the maximum value—the highest level of sustainable development, while 0, the minimum value—the lowest level of sustainable development. Following the calculation of the overall SDG composite index based on the 90 indicators, the highest score of sustainable development was 5.32 at local level (Figure 3) and 5.96 at the county level (Figure 4).

In general, higher scores can be seen in large cities, metropolitan areas, but also in the southeastern part of Romania, in the capital region and in the central and northwestern parts (Figure 3). These areas represent the most developed regions of the country, both from an economic and a social perspective.

At county level, the Municipality of Bucharest, respectively, Timiș, Cluj, Constanța, Brașov, Sibiu, Ialoveni, and Tulcea counties have achieved the highest level of sustainable development, while Vaslui and Teleorman counties are situated at the opposite end (Figure 4). These results suggest differences related to sustainable development across different regions of Romania: the counties in the western part of the country had a higher SDG Index score than those in the east, while northwestern counties had a higher score than southern counties. It must be mentioned that at the level of LAU, among the top ranking localities, we can also find some rural settlements, usually being situated close...
to big urban centers/being part of metropolitan areas, like Dumbrăveni and Giroc close to Timișoara city (Figure 3a), Florești near Cluj-Napoca metropolitan area (Figure 3b) as well as Mogoșoaia and Corbeanca near the capital agglomeration area (Figure 3c). From a social and economic point of view, these communes also stand out as the most developed rural settlements, with reduced social vulnerability and high internal cohesion (Török, 2018). On the other hand, one of the biggest problems which the majority of communes and cities with a low SDG Index score face are the high proportion of elderly people, the limited access to economic resources, and lack of educational and health infrastructure, mainly in isolated and mountainous regions. This fact explains the relatively high share of the population working in (subsistence) agriculture with a negative impact in contributing to the overall SDG goals.

If we look at the performance of the analyzed territories/regions in more detail, we can observe that even the highest ranking counties or LAUs have had to make great efforts in order to improve the overall SDGs. The major concerns are strongly related to climate actions (SDG 13), conservation of terrestrial ecosystems (SDG 15), assuring stable and secure living conditions (SDG 16), strengthening the local and regional cooperation and partnership (SDG 17), and partially eliminating poverty (SDG 1) and reducing inequality (SDG 10) (see Appendix B).

Diminishing interregional income inequalities and combating the risk of poverty and social exclusion have represented two of the main concerns of the EU Member States in the last two decades. Although the European Cohesion Policy concentrates on reducing the existing regional inequalities, studies have shown its continuous increasing during the last two decades mainly at subnational level (Török & Benedek, 2018). The share of the population at risk of relative poverty after social transfers AROP (At Risk Of Poverty) is one of the most important indicators used to assess the risk of poverty or social exclusion in the European Union. It must be mentioned that Romania has one of the highest poverty rates among all EU member states, reaching 23.6% in 2017 as compared to the EU average of 16.9%. What is more, the absolute poverty rate was four times higher in rural than in urban areas (Eurostat, 2020a). Even in the more developed counties where income inequalities are less evident, there is a strong social segregation mainly in big urban centers. Unfortunately, in Romania, there is no available official statistical data on personal income; however, household income inequalities had a main impact role in the decision-making process in order to fight poverty and reduce social inequalities. Using the potential of nighttime lights to measure regional inequalities as well as VIIRS nighttime light data for income estimation at local level, our recent studies have demonstrated that Earth Observation solutions could play an important role in monitoring progress of inequalities (SDG 10) (Ivan, Holobâca, Benedek, & Török, 2020a; Ivan, Holobâca, Benedek, & Török, 2020b). Considering the average value at settlement level, only 46% of the rural and urban areas are relatively close to the SDG 10 average score.
Climate change, as a phenomenon, affects to a certain degree all communities and ecosystems around the world. In Romania, three of the most significant hazards—considering the number of deaths, affected individuals, and economic damages—are strongly related to changes in climate conditions, respectively flood, droughts, and excessive temperatures (EM-DAT, 2020; Török, 2017). We must also take into account that projections related to climate change indicate an increase in the frequency and intensity of these phenomena (Micu, Dumitrescu, Cheval, & Birsan, 2015). All these have roots in the excessive industrialization, deforestation, and large-scale agriculture, complemented by the spatial expansion of the built environment, mainly in large urban centers and their metropolitan areas. Therefore, improving resilience and the adaptive capacity of countries to fight extreme weather patterns represents one of the major targets of the UN under the 13 SDG. Over the last years, tackling with climate change effects has represented an important issue also in Romania. The National Strategy for Climate Change in Romania was approved in July 2013 by the GO 529/2013, focusing on the reduction of vulnerability in specific sectors like agriculture, energy, water resources, transport, industry, construction, urban planning insurance, biodiversity, human health, tourism, forestry, infrastructure, and recreational activities (MECC, 2013). In order to analyze the degree to which SDG 13 goals are achieved and to explore the reasons why some developed areas perform well below the national average, we have included indicators regarding the share of forest areas, growth rates of the built-environment, public expenses related to environmental protection, as well as indices with a great impact on climate change. According to our results, most of the counties—including localities in mountainous areas (i.e., Caraș-Severin, Hunedoara, Vâlcea, Bistrița-Năsăud, Neamț) have achieved a score (above 7) almost two times higher than that of developed counties (around 4). The situation gives reason for concern even in the capital and the surrounding Ilfov county (3.99) where the high population density, the concentration of economic activities, the expansion of built areas, and the intense road traffic have led not only to a severe air pollution but have also increased noise pollution. Behind the Bucharest agglomeration area, the second least favorable place is occupied by Timiș county (4.45), followed by Iași (5.37), Brașov (5.51), Constanța (5.90), and Cluj counties (5.94). Another issue which makes it difficult to achieve progress in the case of SDG 13 is strongly related to the high share of people working in agriculture (in 2019, the rate of people working in primary activities was 20.5%) where the excessive use of pesticides, insecticides along with animal farming activities have negatively influenced the fulfillment of the above mentioned objectives. Localities situated in the southern plain of the country (Brăila, Giurgiu, Ialomița, Teleorman, Călărași) represent the second major group of counties with a relatively low SDG 13 score (between 4.6 and 4.8). It is worth mentioning that the country has committed to reducing GGE emissions by 40% compared to the 1990 levels until 2030 as well as to improving energy efficiency by 27% (Benedek, Sebestyén, & Bartók, 2018; Cebotari & Benedek, 2017; MEWF, 2020).

The third issue, which needs to be improved even in developed areas, is strongly related to the previous one, namely the conservation of the terrestrial ecosystems, combating desertification, and land degradation (SDG 15). The roots of this situation are strongly related to the constrained socio-economic development in the past few decades—mainly to the intense urbanization and industrialization between 1960 and 1989 (Benedek, 2006)—which caused several imbalances on the natural resources such as deforestation and land degradation, water, and air pollution, with direct impact on long-term climate change. This was followed by rapid expansion of human settlements and infrastructural development, which amplified the modification of ecological composition. In these circumstances, Romania has committed to implement several actions addressing the conservation and management of natural resources in order to avoid the degradation of biodiversity and the natural heritage. One of the most important steps in this sense have been represented by the designation of Special Protection Areas and Sites of Community Importance along with the delimitation of new Natura 2000 sites and extending existing ones. According to data from the Ministry of the Environment, there are 1,550 protected areas in Romania, which represent 23% of the total surface of the country, positioning Romania well above the EU average (Romanian Government, 2018). Moreover, a recent evaluation report by the European Commission on the conservation status of habitats and species in Romania has declared that the country has one of the best conservation statuses across the EU (EC, 2019). To examine the SDG of Life and Land, we have included in our analyses all the indicators which are strongly related to natural monuments, parks, and reservations, Natura 2000-, Natura SCI-, and Ramsar Sites, biosphere reserves as well as changes in forest areas in the last decade. In this sense, one of the best-ranked county is Tulcea (6.72) due to the Danube Delta Biosphere Reserve, Europe’s largest wetland which is located here. Tulcea is followed by Caraș-Severin and Mehedinți counties with above average scores (over 4.1) as several renowned national parks are located here. Looking into the objective score, 68.3% of settlements and 59.6% of counties are positioned well-below the national average, among them the most developed areas of the country. Even though there was a positive evolution toward achieving the SDG 15 goals, it is still necessary to elaborate long-term strategies for the protection of the natural environment and especially to combat extreme deforestation. This is especially important in big urban centers where the lack of adequate urban planning has resulted in chaotic residential developments.

Considering the next two SDGs (SDG 16 and SDG 17) where most of the communes and cities, including the more developed ones, perform less well, they are strongly related to fighting corruption, supporting transparency, ensuring participation in the decision-making process as well as strengthening the legislative frameworks. Even though, in the last few years, Romania has made significant progress in decreasing the occurrence of crime, violence, or vandalism (in 2019, 23% less people reported such an occurrence compared to 2010) (Eurostat, 2020b), the country has still not been able to tackle corruption. According to the Transparency International annual report on Corruption Perception Index, in 2018 (Transparency International, 2020), Romania has been positioned in 61 place internationally, being the second most corrupt country in the European Union (after
Bulgaria). In order to monitor the fulfillment of SDG 16, two of the most important indicators included in the analysis are the crime coefficient index and public expenses on defense. Usually communes and small size cities located in the central and northwestern parts of the country are positioned better than large urban agglomerations situated in the southern and eastern parts. This is well illustrated by the fact that the capital, Bucharest and the surrounding Ilfov county have one of the lowest scores (3.57, respectively 4.36).

5 | CONCLUSIONS

The Agenda 2030 has reinvigorated scientific and policy-led interest in indicator-based assessment of progress toward SDGs. Our study proposes a novel approach, called an integrated territorial approach, for the measurement and indicator-based assessment of the SDGs. It quantifies the performance of each LAU on the achievement of the SDGs by including in the measurement both rural and urban areas in Romania. In this regard, we aimed at generating a territorial database on local level, used EO methods in measuring of SDG indicators, and developed a new data model for measuring the SDG index. In order to measure the progress of each commune, city, and county in achieving the SDGs, we calculated the SDG Index at local and county level using 90 indicators. 568 models and the PostgreSQL object–relational database were the basis to process the data and calculate indicators and the SDG Index.

Our approach is novel from another perspective too, namely from the perspective of scale. While the vast majority of previous studies have focused on the national scale, or on the immediate sub-national (regional scale), we have extended the geographical scale of analysis to the local level (LAUs). This approach is off course very sensitive to the indicator selection. In such cases, where it was possible, we have tried to rely on Earth Observation methods, which eliminate the above-mentioned sensitivity.

The integrated territorial approach is transferable to other regions and localities as well. In particular, the indicators calculated on the basis of Earth Observations are very suitable for application in developing regions which face data availability limitations. In the same time, the logic of the territorial database construction and the new data model can be applied in various spatial and national settings.

The calculated SDG Index and the generated Dashboards for Romania reveal that the majority of communes, cities, or counties are far from the achievement of the SDGs. On a scale of 0–10, the highest score of sustainable development was 5.32 at local level and 5.96 at the county level. The large cities, metropolitan areas, the capital region, the southeastern part of Romania, the central and northwestern parts, and some perirurban areas are closest to the SDG targets. Even if these areas represent the most developed areas from an economic and a social perspective, they still face challenges in achieving some SDGs.

Finally, the results of the study will enhance the ability of central authorities to balance sustainable development between national and various subnational levels and to develop implementation strategies and monitor progress. It will also help the local public administration authorities to set up empirically sound and politically relevant Local Development Strategies.

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CONFLICT OF INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

AUTHOR CONTRIBUTIONS

All authors contributed equally to the research presented in this paper and to the preparation of the final manuscript. All authors have read and agreed to the published version of the manuscript.

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REFERENCES

Allen, C., Reid, M., Thwaites, J., Glover, R., & Kestin, T. (2020). Assessing national progress for the Sustainable Development Goals (SDGs): Experience from Australia. Sustainability Science, 15, 521–538. https://doi.org/10.1007/s11205-019-00711-x
Benedek, J. (2006). Urban policy and urbanisation in the transition Romania. Romanian Review of Regional Studies, 1, 51–64.
Benedek, J., & Lembcke, A. C. (2017). Characteristics of recovery and resilience in the Romanian regions. Eastern Journal of European Studies, 8 (2), 95–126.
Benedek, J., Sebestyén, T., & Bartók, B. (2018). Evaluation of renewable energy sources in peripheral areas and renewable energy-based rural development. Renewable and Sustainable Energy Reviews, 90(7), 516–535. https://doi.org/10.1016/j.rser.2018.03.020
Bolcárová, P., & Kolostá, S. (2015). Assessment of sustainable development in the EU 27 using aggregated SD index. Ecological Indicators, 48, 699–705. https://doi.org/10.1016/j.ecolind.2014.09.001
Campagnolo, L., Carraro, C., Eboli, F., Famia, L., Parrado, R., & Pierferdici, R. (2018). The ex-ante evaluation of achieving sustainable development goals. Social Indicators Research, 136, 73–116. https://doi.org/10.1007/s11205-017-1572-x
Cavalli, L., & Famia, L. (2018). Per un’Italia Sostenibile: l’SDSN Italia SDGs City Index 2018. Milan, Italy: Fondazione Eni Enrico Mattei.
Cebotari, S., & Benedek, J. (2017). Renewable energy project as a source on innovation in rural communities. Sustainability, 9(4), 509. https://doi.org/10.3390/su9040509
Corbane, C., Politis, P., Siragusa, A., Kemper, T., & Pesaresi, M. (2017). LUE User Guide: A Tool to Calculate the Land Use Efficiency and the SDG 11.3 Indicator with the Global Human Settlement Layer. Luxembourg: Publications Office of the European Union.
Dalampira, E.-S., & Nastis, S. A. (2019). Mapping sustainable development goals: A network analysis framework. Sustainable Development, 28, 46–55. https://doi.org/10.1002/sd.1964
Ecological Indicators, 10, 407–418. https://doi.org/10.1016/j.ecolind.2009.07.013
Thom, E. C. (1958). Cooling degree days. Air Conditioning, Heating and Ventilating 55, 65–69.
Tomalty, R., Alexander, D., Anielski, M., Wilson, J., Jozsa, A., Haider, M., ... Casey, D. (2007). Ontario community sustainability report—2007. Nanaimo, Canada: Vancouver Island University.
Török, I. (2017). Assessment of social vulnerability to natural hazards in Romania. Carpathian Journal of Earth and Environmental Sciences, 12, 549–562.
Török, I. (2018). Quality assessment of social vulnerability to flood hazards in Romania. Sustainability, 10, 3780. https://doi.org/10.3390/su10103780
Török, I., & Benedek, J. (2018). Spatial patterns of local income inequalities. Journal of Settlements and Spatial Planning, 9(2), 77–91. https://doi.org/10.24193/JSSP.2018.2.01
Transparency International. (2020). Tools to support transparency in local governance. Retrieved from https://www.transparency.org/en/publications/tools-to-support-transparency-in-local-governance
van Meijgaard, E., van Ulft, L. H., van de Berg, W. J., Bosveld, F. C., van den Hurk, B. J. M., Lenderink, G., & Siebesma A. P. (2008). The KNMI regional atmospheric climate model, version 2.1. KNMI Tech. Rep. 302. R. Neth. Meteorol. Inst., De Bilt, Netherlands, p. 50.
Weitz, N., Carlsen, H., Nilsson, M., & Skånberg, K. (2017). Towards systemic and contextual priority setting for implementing the 2030 Agenda. Sustainability Science, 13, 531–548. https://doi.org/10.1007/s11625-017-0470-0
Wichaisri, S., & Sopadang, A. (2018). Trends and future directions in sustainable development. Sustainable Development, 26, 1–17. https://doi.org/10.1002/sd.1687
Xu, Z., Chau, S. N., Chen, X., Zhang, J., Li, Y., Dietz, T., ... Liu, J. (2020). Assessing progress towards sustainable development over space and time. Nature, 577, 74–78. https://doi.org/10.1038/s41586-019-1846-3
Yap, B. W., & Sim, C. H. (2011). Comparisons of various types of normality tests. Journal of Statistical Computation and Simulation, 18, 2141–2155. https://doi.org/10.1080/00949655.2010.520163

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### APPENDIX A

Summary statistics for indicators included in the SDG dashboards

| SDG | Indicators                                                                 | Obs | Mean    | SD      | Min     | Max     | W   | z  | Prob > z |
|-----|---------------------------------------------------------------------------|-----|---------|---------|---------|---------|-----|-----|----------|
| 1   | Revenues per capita (RON/person)                                          | 42  | 1,071.347 | 337.429 | 300.573 | 3,621.873 | 0.695 | 5.335 | 0.000    |
| 1   | Public expenses per capita (RON/person)                                   | 42  | 2,448.970  | 496.325 | 1740.100 | 4,594.243 | 0.832 | 4.078 | 0.000    |
| 1   | Social public expenses (RON/person)                                       | 42  | 226.739     | 72.144  | 124.850 | 402.640 | 0.920 | 2.518 | 0.006    |
| 1   | Youth not in employment, education, or training (NEET) %                  | 42  | 24.137      | 4.769   | 8.242   | 33.246 | 0.935 | 2.128 | 0.017    |
| 2   | Agricultural area (% of total area)                                       | 42  | 57.104      | 19.407  | 13.983  | 86.797 | 0.976 | 0.624 | 0.266    |
| 3   | Infant mortality rate (per 1,000 people)                                 | 42  | 6.929       | 2.405   | 2.805   | 15.300 | 0.982 | 0.444 | 0.740    |
| 3   | Medical-sanitary staff density (per 1,000 people)                        | 42  | 9.627       | 2.988   | 5.972   | 19.892 | 0.861 | 3.675 | 0.000    |
| 3   | Physician density (per 1,000 people)                                     | 42  | 17.045      | 1.878   | 12.765  | 23.048 | 0.967 | 0.624 | 0.266    |
| 3   | Share of elderly population (%)                                          | 42  | 14.587      | 1.367   | 12.269  | 17.493 | 0.971 | 0.360 | 0.359    |
| 3   | Share of young population (%)                                            | 42  | 24.137      | 4.769   | 8.242   | 33.246 | 0.935 | 2.128 | 0.017    |
| 3   | Number of the beds from sanitary units (per 1,000 people)                | 42  | 5.457       | 1.603   | 2.956   | 10.347 | 0.944 | 1.767 | 0.039    |
| 3   | Civil economically active population (%)                                  | 42  | 41.906      | 2.572   | 36.231  | 47.440 | 0.976 | 0.075 | 0.530    |
| 3   | Share of population with higher education (%)                            | 42  | 0.122       | 0.048   | 0.068   | 0.337  | 0.804 | 0.439 | 0.000    |
| 3   | Illiterate population (%)                                                 | 42  | 0.016       | 0.008   | 0.002   | 0.040  | 0.898 | 3.028 | 0.001    |
| 3   | Share of population without education (%)                                | 42  | 3.185       | 1.075   | 0.009   | 5.067  | 0.971 | 0.333 | 0.369    |
| 3   | Population 25 and above with upper-, postsecondary, nontertiary educ (%) | 42  | 13.684      | 6.312   | 7.335   | 45.371 | 0.701 | 5.294 | 0.000    |
| 3   | Education units (per 1,000 people)                                       | 42  | 0.315       | 6.649   | −6.931  | 30.251 | 0.744 | 4.962 | 0.000    |
| 3   | Migratory increase of the population (per 1,000 people)                  | 42  | −3.785      | 2.511   | −10.176 | 1.790  | 0.991 | −2.074 | 0.981    |
| 3   | Public expenses on health (RON/person)                                   | 42  | 60.842      | 37.774  | 17.023  | 250.268 | 0.677 | 5.458 | 0.000    |
| 4   | Share of population with higher education (%)                            | 42  | 0.122       | 0.048   | 0.068   | 0.337  | 0.804 | 0.439 | 0.000    |
| 4   | Share of population without education (%)                                | 42  | 3.185       | 1.075   | 0.009   | 5.067  | 0.971 | 0.333 | 0.369    |
| 4   | Share of population aged 25 and above with higher educ (%)               | 42  | 13.684      | 6.312   | 7.335   | 45.371 | 0.701 | 5.294 | 0.000    |
| 4   | Share of population 25 and above with upper-, postsecondary, nontertiary educ (%) | 42  | 17.304      | 6.683   | 9.396   | 50.223 | 0.737 | 5.020 | 0.000    |
| 4   | Education units (per 1,000 people)                                       | 42  | 0.314       | 0.042   | 0.235   | 0.436  | 0.973 | 0.183 | 0.428    |
| 4   | Share of female unemployed (%)                                           | 42  | 1.831       | 0.760   | 0.300   | 3.600  | 0.952 | 1.421 | 0.078    |
| 6   | Sewer network density (km/km²)                                           | 42  | 0.507       | 2.283   | 0.048   | 14.938 | 0.167 | 7.455 | 0.000    |
| 7   | Access to current water (% of total dwellings)                           | 42  | 0.768       | 0.118   | 0.485   | 0.997  | 0.979 | −0.268 | 0.606    |
| 7   | Access to hot water (% of total dwellings)                               | 42  | 0.549       | 0.151   | 0.281   | 0.963  | 0.975 | 0.061 | 0.476    |
| 7   | Access to central heating (% of total dwellings)                         | 42  | 61.429      | 15.560  | 30.500  | 96.600 | 0.986 | −1.106 | 0.866    |
| 7   | Access to electricity (% of total dwellings)                             | 42  | 98.734      | 0.636   | 97.341  | 99.851 | 0.948 | 1.613 | 0.053    |
| 8   | Automated teller machines and banks (per 1,000 people)                   | 42  | 0.150       | 0.105   | 0.041   | 0.505  | 0.834 | 4.049 | 0.000    |
| 8   | Employment to population ratio (%)                                       | 42  | 20.597      | 6.842   | 10.931  | 45.042 | 0.901 | 2.956 | 0.002    |
| 8   | Unemployment rate (%)                                                    | 42  | 1.983       | 0.926   | 0.300   | 4.200  | 0.931 | 2.210 | 0.014    |
| SDG | Indicators                                                                 | Obs | Mean  | SD   | Min  | Max  | W    | z     | Prob > z |
|-----|---------------------------------------------------------------------------|-----|-------|------|------|------|------|-------|---------|
|     | Establishments of touristic reception (per 1,000 people)                  | 42  | 0.807 | 0.737| 0.084| 3.030| 0.829| 4.108 | 0.000   |
| 9   | Degree of use of touristic accommodation capacity                         | 42  | 0.539 | 0.180| 0.174| 0.966| 0.965| 0.766 | 0.222   |
|     | Natural gas network density (km/km²)                                      | 42  | 0.392 | 1.332| 0.011| 8.697| 0.233| 7.280 | 0.000   |
|     | Water network density (km/km²)                                            | 42  | 0.394 | 1.544| 0.150| 10.323| 0.206| 7.353 | 0.000   |
|     | Road density (km/km²)                                                     | 42  | 0.368 | 0.087| 0.160| 0.518| 0.982| −0.666| 0.747   |
|     | National road accessibility (km)                                          | 42  | 388.513| 109.058| 81.190| 623.008| 0.978| −0.197| 0.578   |
|     | County road accessibility (km)                                            | 42  | 2.045 | 0.173| 1.697| 2.487| 0.981| −0.531| 0.702   |
|     | School teachers (per 30 pupils)                                          | 42  | 452.611| 138.110| 252.644| 883.163| 0.930| 2.219 | 0.013   |
|     | Railway density (km/km²)                                                  | 42  | 0.054 | 0.060| 0.012| 0.407| 0.427| 6.665 | 0.000   |
| 10  | Local Human Development Index                                             | 42  | 71.833| 8.887| 56.000| 102.000| 0.940| 1.904 | 0.028   |
| 11  | Finished dwellings (per 10,000 people)                                    | 42  | 1.370 | 0.255| 0.742| 1.933| 0.973| 0.250 | 0.401   |
|     | Population density (people per km²)                                       | 42  | 4.608 | 3.580| 0.803| 24.180| 0.595| 5.931 | 0.000   |
|     | Population growth rate (%)                                                | 42  | 216.534| 114.045| 88.847| 802.380| 0.686| 5.395 | 0.000   |
|     | Access to bath (% of total dwellings)                                     | 42  | 226.739| 72.144| 124.850| 402.640| 0.920| 2.518 | 0.006   |
|     | Access to water-closet (% of total dwellings)                             | 42  | 23.485| 26.254| 3.489| 131.831| 0.646| 5.646 | 0.000   |
|     | Land use efficiency                                                       | 42  | 293.000| 1,321.545| 28.053| 8,649.474| 0.161| 7.469 | 0.000   |
|     | Living floor (m² per person)                                              | 42  | −0.003| 0.008| −0.016| 0.034| 0.806| 4.379 | 0.000   |
|     | Traffic deaths rate (per 1,000 people)                                    | 42  | 58.222| 15.040| 33.299| 98.389| 0.960| 1.023 | 0.153   |
|     | Serious traffic accidents rate (per 1,000 people)                         | 42  | 56.765| 15.296| 33.329| 98.398| 0.960| 2.982 | 0.001   |
|     | Slight traffic accidents rate (per 1,000 people)                          | 42  | 2.782 | 0.131| 2.502| 3.224| 0.964| 0.852 | 0.197   |
|     | Housing density (number of people per room)                               | 42  | 2.699 | 0.121| 2.400| 3.050| 0.979| −0.306| 0.620   |
|     | Average number of people per household (number)                           | 42  | 0.375 | 0.135| 0.103| 0.676| 0.976| −0.070| 0.528   |
|     | Building permits (per 1,000 people)                                       | 42  | 1.400 | 0.310| 0.575| 2.032| 0.973| 0.229 | 0.409   |
|     | Public expenses on housing, services and public development (RON/capita)  | 42  | 19.323| 2.346| 14.422| 29.303| 0.857| 3.734 | 0.000   |
| 12  | Access to wastewater network/septic tank (% of dwellings)                 | 42  | 0.648 | 0.156| 0.371| 0.991| 0.977| −0.136| 0.554   |
| 13  | Forest areas (% of total area)                                            | 42  | 28.288| 17.280| 2.644| 58.563| 0.926| 2.353 | 0.009   |
|     | Cooling index (CI)- days with minimum temperatures below −15°C.          | 42  | 1.065 | 1.106| 0.042| 5.400| 0.716| 5.186 | 0.000   |
|     | Temperature humidity index (THI)                                          | 42  | 23.101| 12.149| 4.533| 45.394| 0.930| 2.239 | 0.013   |
|     | Growth rate of built-up areas (%)                                        | 42  | 4.804 | 3.950| 0.148| 16.148| 0.875| 3.449 | 0.000   |
|     | Public expenses on environmental protection (RON/capita)                  | 42  | 144.332| 67.543| 66.777| 394.488| 0.853| 3.796 | 0.000   |
|     | Average annual concentration of nitrogen oxides (NO₂)                    | 42  | 0.000 | 0.000| 0.000| 0.000| 0.636| 5.705 | 0.000   |
| 14  | Water bodies (% of total area)                                            | 42  | 1.673 | 2.043| 0.088| 12.687| 0.579| 6.012 | 0.000   |
| 15  | Natural monument (% of total area)                                       | 42  | 0.055 | 0.135| 0.000| 0.779| 0.450| 6.578 | 0.000   |
|     | National parks (% of total area)                                         | 42  | 1.127 | 2.446| 0.000| 11.813| 0.654| 5.603 | 0.000   |
|     | Natural parks (% of total area)                                          | 42  | 3.112 | 6.564| 0.000| 32.109| 0.565| 6.081 | 0.000   |
|     | Biosphere reserves (% of total area)                                     | 42  | 1.620 | 7.753| 0.000| 49.821| 0.368| 6.872 | 0.000   |
|     | Natural reservations (% of total area)                                    | 42  | 1.041 | 1.349| 0.000| 6.173| 0.733| 5.050 | 0.000   |
|     | Strictly protected reservations (% of total)                              | 42  | 0.072 | 0.215| 0.000| 1.315| 0.426| 6.669 | 0.000   |

(Continues)
### APPENDIX B.

| SDG Indicators                                      | Obs | Mean     | SD         | Min | Max | W     | z      | Prob > z |
|-----------------------------------------------------|-----|----------|------------|-----|-----|-------|--------|----------|
| Natura SCI sites (% of total area)                  | 42  | 15.091   | 12.217     | 0.000 | 62.668 | 0.851 | 3.827  | 0.000    |
| Ramsar sites (% of total)                           | 42  | 27.846   | 19.784     | 0.000 | 100.000 | 0.883 | 3.305  | 0.000    |
| SPA protected areas (% of total area)               | 42  | 3.363    | 8.799      | 0.000 | 51.342 | 0.521 | 6.285  | 0.000    |
| Surface of protected areas (% of total area)        | 42  | 13.609   | 12.661     | 0.000 | 73.203 | 0.732 | 5.064  | 0.000    |
| Change in forest area (%)                           | 42  | 21.520   | 14.802     | 0.000 | 74.294 | 0.882 | 3.322  | 0.000    |
| Public expenses on defense (RON/capita)             | 42  | 0.462    | 0.102      | 0.167 | 0.712 | 0.972 | 0.316  | 0.376    |
| Crime coefficient (Index)                           | 42  | 53.641   | 20.382     | 22.086 | 134.185 | 0.846 | 3.888  | 0.000    |
| Proportion of the population using internet (%)     | 42  | 99.999   | 8.546      | 18.361 | 61.807 | 0.964 | 0.851  | 0.197    |
| Number of libraries (per 1,000 people)              | 42  | 34.118   | 8.546      | 18.361 | 61.807 | 0.964 | 0.851  | 0.197    |
| Number of museums (per 1,000 people)               | 42  | 0.036    | 0.025      | 0.011 | 0.151 | 0.751 | 4.905  | 0.000    |
| EU funds revenues (RON/capita)                      | 42  | 90.747   | 95.143     | 1.270 | 598.746 | 0.600 | 5.905  | 0.000    |
| National programs funds revenues (RON/capita)       | 42  | 138.399  | 73.865     | 0.000 | 435.865 | 0.880 | 3.361  | 0.000    |

SDG dashboards at county level [Colour figure can be viewed at wileyonlinelibrary.com]