

JRC TECHNICAL REPORTS

JRC Statistical Audit of the Sustainable Development Goals Index and Dashboards

Papadimitriou, Eleni
Neves, Ana Rita
Becker, William

2019



This publication is a Technical report by the Joint Research Centre (JRC), the European Commission's science and knowledge service. It aims to provide evidence-based scientific support to the European policymaking process. The scientific output expressed does not imply a policy position of the European Commission. Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use that might be made of this publication.

Report completed in May 2019.

Contact information

European Commission
Joint Research Centre
Directorate for Competences
Monitoring, Indicators and Impact Evaluation Unit
Competence Centre on Composite Indicators and Scoreboards
E-mail: jrc-coin@ec.europa.eu
<https://ec.europa.eu/jrc/en/coin>
<https://composite-indicators.jrc.ec.europa.eu/>

EU Science Hub

<https://ec.europa.eu/jrc>

JRC116857

EUR 29776 EN

PDF ISBN 978-92-76-08995-7 ISSN 1831-9424 doi:10.2760/723763

Luxembourg: Publications Office of the European Union, 2019

© European Union, 2019

The reuse policy of the European Commission is implemented by Commission Decision 2011/833/EU of 12 December 2011 on the reuse of Commission documents (OJ L 330, 14.12.2011, p. 39). Reuse is authorised, provided the source of the document is acknowledged and its original meaning or message is not distorted. The European Commission shall not be liable for any consequence stemming from the reuse. For any use or reproduction of photos or other material that is not owned by the EU, permission must be sought directly from the copyright holders.

All content © European Union, 2019

How to cite this report: Papadimitriou, E.; Neves, A. R.; Becker, W., JRC Statistical Audit of the Sustainable Development Goals Index and Dashboards, EUR 29776 EN, 2019, ISBN 978-92-76-08995-7, doi:10.2760/723763, JRC116857.

Contents

Abstract	2
1 Introduction.....	3
2 Conceptual and statistical coherence.....	4
2.1 Relevance to the SDG Index framework.....	4
2.2 Data availability.....	5
2.3 Identification and treatment of outliers.....	9
2.4 Normalisation.....	9
2.5 Weighting and aggregation	9
2.6 Cross-correlation analysis	10
2.7 Principal components analysis	13
3 Impact of modelling assumptions on the SDG Index results	16
4 Communication on the SDG Index results.....	20
5 Conclusions	23
References	24
Annex I – List of indicators included in the 2019 SDG Index.....	25
Annex II - Median ranks of countries with 95% confidence intervals	28

Abstract

In 2015, the United Nations adopted the 2030 Agenda for Sustainable Development with 17 Sustainable Development Goals (SDGs) and 169 associated targets. All 193 United Nations member states have committed to achieve sustainable development across its three dimensions – economic, social, and environmental – in a balanced and integrated manner. In order to assist countries in measuring their progress towards the achievement of the SDGs, Bertelsmann Stiftung and the United Nations Sustainable Development Solutions Network (SDSN) developed the Sustainable Development Goals Index and Dashboards (SDG Index) in 2016. Since then, the SDG Index has been annually updated and presently covers 162 countries. The European Commission's Competence Centre on Composite Indicators and Scoreboards (COIN) at the Joint Research Centre (JRC) was invited by the SDSN to audit the 2019 edition of the SDG Index which will be launched on the sidelines of the 2019 United Nations High-level Political Forum on Sustainable Development. The audit presented herein aims to contribute to ensuring the transparency of the SDG Index methodology and the reliability of the results. The report touches upon data quality issues, the conceptual and statistical coherence of the framework and the impact of modelling assumptions on the results. The fact that the SDGs are universal and highly diverse in nature makes the work of aggregating into a single number quite challenging from a statistical point of view. Nevertheless, the SDG Index is a remarkable effort of synthesizing the 17 SDGs into a single measure. The index ranks are robust enough, allowing meaningful conclusions to be drawn from the index.

1 Introduction

The 2030 Agenda for Sustainable Development and its 17 Sustainable Development Goals (SDGs) was adopted by all 193 United Nations (UN) member states in 2015. The implementation and success of this universal agenda will rely on all countries and will require national sustainable development policies and multi-stakeholder partnerships.

Sound metrics are critical for turning the SDGs into practical tools for problem solving by mobilising governments, academia, civil society and business; providing a report card to track progress and ensure accountability; and serving as a management tool for the transformations needed to achieve the SDGs by 2030. Countries are expected to voluntarily establish national frameworks for monitoring progress made on the 17 SDGs. The UN High-Level Political Forum plays a central role in following up and reviewing progress at the global level.

In order to assist countries in the annual stocktaking of SDGs progress, Bertelsmann Stiftung and the Sustainable Development Solutions Network (SDSN) launched in 2016 the first edition of the Sustainable Development Goals Index and Dashboards (SDG Index). The SDG Index is a composite measure of progress covering 85 indicators across all 17 goals. Now in its 2019 edition, the SDG Index includes 162 countries, while the dashboards present data for all 193 UN member states. Additional metrics are also provided on the dashboards and country profiles of members of the Organisation for Economic Co-operation and Development (OECD).

The European Commission's Competence Centre on Composite Indicators and Scoreboards (COIN) at the Joint Research Centre (JRC) was invited by the SDSN to audit the 2019 edition of the SDG Index which will be launched on the sidelines of the 2019 United Nations High-level Political Forum on Sustainable Development in July in New York.

The results of the audit presented herein aim at shedding light on the transparency and reliability of the SDG Index. It is expected to contribute to enable policymakers and advocates to derive more accurate and meaningful conclusions and to potentially guide choices on priority setting and policy formulation.

The JRC statistical audit¹ of the SDG Index focuses on two main issues: the statistical coherence of the structure of indicators (Section 2) and the impact of key modelling assumptions on the SDG Index ranking (Section 3). The audit follows three main steps: the first focuses on the main descriptive statistics of the data and on a data analysis to detect missing values and potential outliers; the second on the analysis of the statistical coherence through a multilevel analysis of the correlations of the indicators and pillars, and; the third, on the robustness analysis of the index and the testing of the impact of key modelling assumptions. The results are supported by a spreadsheet in Excel format [1].

The JRC analysis also complements the reported country rankings for the SDG index with confidence intervals in order to better appreciate the robustness of these ranks to the computation methodology (in particular the exclusion of potentially problematic indicators, weights and aggregation formula at the goals level).

An initial assessment on the 2018 edition of the SDG Index [2] [3] was undertaken by the JRC in February 2019 [4]. The latest 2019 edition provided by the developers incorporated many of the JRC suggestions and for some of the identified issues the developers provided strong arguments for using a different approach.

¹ The JRC statistical audit is based on the recommendations of the OECD & JRC (2008) Handbook on Composite Indicators and on more recent research from the JRC. JRC audits of composite indicators are conducted upon request of their developers. For more information see: <https://composite-indicators.jrc.ec.europa.eu>

2 Conceptual and statistical coherence

2.1 Relevance to the SDG Index framework

The conceptual framework of the SDG Index mirrors the 17 SDGs agreed by all UN member states (Table 1). It includes 85 indicators (listed in Annex I) grouped into 17 goals, which are subsequently aggregated into the SDG Index. The overall index is calculated as the simple arithmetic average of the 17 goals.

While another structure could have been adopted, such as the triple bottom line framework – Environmental, Social and Economic, or the 5Ps framework – People, Planet, Prosperity, Peace and Partnership, the authors of the SDG Index decided to maintain the alignment with the global SDGs framework and in this way assist countries to measure their baselines and progress in each of the 17 SDGs. The choice of aggregating indicators in the 17 goals to link to the 2030 global policy agenda [5] is conceptually well justified and responds to a political need of tracking progress at goal level.

The indicators were selected based on five criteria: relevance to monitoring the achievement of the SDGs; statistical adequacy; timeliness; data quality and coverage. Expert consultation was used in the process of selecting the indicators.

The conceptual relevance of the indicators underpinning the SDG index framework is not discussed in this report. One remark though, is that their number across SDGs is uneven, ranging from SDG10 with only one indicator to SDG3 with 14 indicators. As acknowledged by the authors, this means that those 14 indicators in SDG3 weight individually less than the single indicator in SDG10.

Table 1. Conceptual framework of the SDG Index.

Sustainable Development Goal (SDG)		Number of indicators
SDG1	No Poverty	2
SDG2	Zero Hunger	7
SDG3	Good Health and Well-being	14
SDG4	Quality Education	3
SDG5	Gender Equality	4
SDG6	Clean Water and Sanitation	5
SDG7	Affordable and Clean Energy	3
SDG8	Decent Work and Economic Growth	5
SDG9	Industry, Innovation and Infrastructure	6
SDG10	Reduced Inequality	1
SDG11	Sustainable Cities and Communities	3
SDG12	Responsible Consumption and Production	6
SDG13	Climate Action	4
SDG14	Life Below Water	4
SDG15	Life on Land	5
SDG16	Peace and Justice Strong Institutions	9
SDG17	Partnerships to Achieve the Goal	4

2.2 Data availability

The 2019 SDG index was calculated for 162 countries. This coverage implies five additional countries in comparison with the last edition (Maldives, Fiji, Sao Tome and Principe, Vanuatu and Comoros). Additionally, the index is based on reliable and publicly available data published by official international data providers (e.g. World Bank, WHO, ILO, among others) and other international organisations including research centres and non-governmental organisations. This is an important point given that the quality and adequacy of the index lies not only on the index development, but also on obtaining reliable data.

Table 2 offers summary statistics for the indicators included in the SDG Index using the raw data and highlights the cases in which specific issues were found in terms of data coverage and presence of outliers. In the table some preliminary imputations made by the developers' team are included.

Moreover, for each indicator, sustainability "targets" were determined either based on explicit/implicit SDGs targets, science-based targets or average performance of the best performers [3]. At the same time, to remove the effect of extreme values, the developers capped the data at the bottom 2.5th percentile as the minimum value for the normalisation. These upper and lower bounds remain the same over the annual editions of the index and are included in Table 2. The JRC recommended approach would be to only treat data in specific cases where it is needed, however the developers argue that this approach is adopted in order to facilitate comparability of the results.

Table 2. Summary statistics of the indicators (raw data) included in the SDG Index.

Goal	Indicator	Number of observations	Missing data (%)	Mean	Skewness	Kurtosis	Minimum value	Maximum value	Lower bound	Upper bound	Direction
SDG1	1a	151	6.8	11.6	1.8	2.4	0.0	76.9	72.6	0.0	-1
	1b	151	6.8	21.9	1.1	0.0	0.0	93.1	51.5	0.0	-1
SDG2	2a	154	4.9	11.0	1.8	2.9	1.2	61.8	42.3	0.0	-1
	2b	159	1.9	17.8	0.6	-0.9	1.3	55.9	50.2	0.0	-1
	2c	159	1.9	4.8	1.3	1.4	0.0	21.5	16.3	0.0	-1
	2d	161	0.6	18.3	-0.1	-1.1	2.1	37.9	35.1	2.8	-1
	2e	159	1.9	3.5	2.7	15.0	0.2	21.5	0.2	8.6	1
	2f	136	16.0	0.8	-0.5	0.1	0.3	1.3	1.2	0.0	-1
	2g	152	6.2	2.3	0.0	-0.9	2.0	2.6	2.5	2.0	-1
SDG3	3a	162	0.0	165.8	2.0	4.4	3.0	1360	814.0	3.4	-1
	3b	162	0.0	12.8	0.8	-0.4	0.9	44.2	39.7	1.1	-1
	3c	162	0.0	29.0	1.2	0.7	2.1	123.2	130.1	2.6	-1
	3d	162	0.0	107.6	1.8	2.9	0.8	665	561.0	0.0	-1
	3e	162	0.0	0.5	4.5	21.7	0.0	9.1	5.5	0.0	-1
	3f	162	0.0	18.5	0.1	-0.8	7.8	30.6	31.0	9.3	-1
	3g	162	0.0	90.5	0.9	0.1	7.0	324	368.8	0.0	-1
	3h	162	0.0	17.2	0.3	-0.7	2.9	45.4	33.7	3.2	-1
	3i	162	0.0	72.1	-0.5	-0.6	52.9	84.2	54.0	83.0	1
	3j	162	0.0	48.5	1.0	0.6	1.7	194	139.6	2.5	-1
	3k	156	3.7	86.1	-1.4	0.9	20.2	100	23.1	100.0	1
	3l	162	0.0	86.6	-1.7	2.4	37.0	99.0	41.0	100.0	1
	3m	162	0.0	69.6	-0.1	-1.0	30.3	95.7	38.2	100.0	1
	3n	156	3.7	5.5	-0.1	-0.7	2.7	7.9	3.3	7.6	1
SDG4	4a	152	6.2	90.4	-2.0	5.5	36.8	100.0	53.8	100.0	1
	4b	136	16.0	88.6	-1.7	1.8	30.8	100.0	18.0	100.0	1
	4c	151	6.8	74.6	-0.6	-0.7	10.0	116.1	45.2	100.0	1
SDG5	5a	159	1.9	63.0	-0.6	-0.7	12.9	96.6	17.5	100.0	1
	5b	157	3.1	88.7	-1.0	0.5	31.7	127.3	41.8	100.0	1
	5c	162	0.0	71.5	-1.0	0.7	8.4	110.3	21.5	100.0	1
	5d	162	0.0	22.7	0.5	-0.1	0.0	61.3	1.2	50.0	1
SDG6	6a	162	0.0	86.4	-1.3	0.6	36.6	100.0	40.0	100.0	1
	6b	162	0.0	73.5	-0.8	-0.8	7.1	100.0	9.7	100.0	1
	6c	161	0.6	65.0	7.4	56.7	0.0	2603.5	100.0	12.5	-1
	6d	156	3.7	9.9	4.9	28.2	0.1	148.2	42.6	0.1	-1
	6e	156	3.7	26.6	1.0	-0.6	0.0	100.0	0.0	100.0	1
SDG7	7a	162	0.0	82.1	-1.3	0.2	7.6	100.0	9.1	100.0	1
	7b	160	1.2	65.8	-0.6	-1.2	0.6	100.0	2.0	100.0	1
	7c	133	17.9	1.7	6.4	45.2	0.1	22.6	5.9	0.0	-1
SDG8	8a	158	2.5	-2.1	-0.9	2.9	-14.5	7.2	-14.7	5.0	1
	8b	143	11.7	5.3	3.4	17.2	0.3	40.0	22.0	0.0	-1
	8c	151	6.8	59.2	0.0	-1.3	6.4	99.9	8.0	100.0	1
	8d	162	0.0	7.3	1.7	2.9	0.1	28.5	25.9	0.5	-1
	8e	161	0.6	0.8	4.7	26.6	0.0	12.4	6.0	0.0	-1

Notes: Indicators shaded in red have absolute skewness greater than 2.0 and kurtosis greater than 3.5 and/or data coverage below 80%. The list of indicators is provided in Annex I.

* Only for the 51 High Income & OECD countries included in the country list. ** Excluding the High Income & OECD countries.

Source: European Commission's Joint Research Centre, 2019.

Table 2. Summary statistics of the indicators (raw data) included in the SDG Index. (cont.)

Goal	Indicator	Number of observations	Missing data (%)	Mean	Skewness	Kurtosis	Minimum value	Maximum value	Lower bound	Upper bound	Direction
SDG9	9a	162	0.0	53.1	-0.1	-1.3	4.3	98.3	2.2	100.0	1
	9b	162	0.0	64.1	0.9	1.8	0.0	243.4	1.4	100.0	1
	9c	155	4.3	2.7	0.8	-0.3	1.6	4.4	1.8	4.2	1
	9d	162	0.0	20.0	1.0	0.2	0.0	94.3	0.0	91.0	1
	9e	162	0.0	0.4	1.7	1.7	0.0	2.5	0.0	2.2	1
	9f	132	18.5	0.8	1.7	2.5	0.0	4.3	0.0	3.7	1
SDG10	10a	148	8.6	42.1	0.5	-0.2	26.7	67.1	63.0	27.5	-1
SDG11	11a	162	0.0	28.3	1.6	2.4	5.9	99.7	87.0	6.3	-1
	11b	152	6.2	84.2	-1.6	2.1	7.4	100.0	6.1	100.0	1
	11c	156	3.7	57.6	-0.7	0.6	7.9	85.3	21.0	82.6	1
SDG12	12a	146	9.9	1.3	1.9	5.2	0.1	5.7	3.7	0.1	-1
	12b	154	4.9	8.1	0.8	-0.4	0.4	28.5	23.5	0.2	-1
	12c	143	11.7	14.5	3.9	19.2	0.4	176.3	68.3	0.5	-1
	12d	161	0.6	2.0	0.6	6.3	-52.0	60.9	30.1	0.0	-1
	12e	141	13.0	28.2	1.8	5.0	1.0	139.8	86.5	2.3	-1
	12f	124	23.5	7.3	-0.6	11.1	-1223.4	965.4	432.4	0.0	-1
SDG13	13a	162	0.0	4.5	3.3	16.1	0.0	47.5	23.7	0.0	-1
	13b	160	1.2	0.0	-5.0	37.0	-19.5	4.3	3.2	0.0	-1
	13c	141	13.0	2421.3	3.4	12.2	0.0	31953	18000	0.0	-1
	13d	148	8.6	4605.7	6.3	46.8	0.0	160773	44000	0.0	-1
SDG14	14a	114	29.6	46.0	0.1	-1.2	0.0	99.6	0.0	100.0	1
	14b	123	24.1	54.2	0.0	0.1	15.1	94.0	28.6	100.0	1
	14c	96	40.7	31.7	0.7	-0.1	0.1	100.0	90.7	0.0	-1
	14d	111	31.5	32.2	0.8	-0.5	0.0	97.4	90.0	1.0	-1
SDG15	15a	158	2.5	46.6	0.2	-1.1	0.0	99.4	4.6	100.0	1
	15b	129	20.4	49.9	0.1	-1.2	0.0	100.0	0.0	100.0	1
	15c	162	0.0	0.9	-1.0	1.7	0.4	1.0	0.6	1.0	1
	15d	138	14.8	0.2	3.5	14.4	0.0	2.9	1.5	0.0	-1
	15e	160	1.2	6.5	6.5	54.5	0.0	140.2	26.4	0.1	-1
SDG16	16a	162	0.0	7.1	3.6	16.1	0.3	82.8	38.0	0.3	-1
	16b	148	8.6	0.3	0.6	-0.8	0.0	0.8	0.8	0.1	-1
	16c	155	4.3	61.8	-0.1	-0.4	12.5	94.2	33.0	90.0	1
	16d	144	11.1	4.3	0.4	-0.3	1.8	6.6	2.5	6.3	1
	16e	149	8.0	84.3	-1.7	1.8	2.7	100.0	11.3	100.0	1
	16f	160	1.2	43.2	0.8	-0.3	13.0	88.0	13.0	88.6	1
	16g	139	14.2	12.6	1.1	0.5	0.0	55.8	39.3	0.0	-1
	16h	162	0.0	0.3	5.8	43.5	0.0	10.2	3.4	0.0	-1
	16i	160	1.2	34.1	0.9	0.6	7.6	84.2	80.0	10.0	-1
SDG17	17a	148	8.6	7.9	0.4	-0.1	1.0	17.9	0.0	15.0	1
	17b1*	36*	29.4	0.4	1.2	0.1	0.1	1.0	0.1	1.0	1
	17b2**	95**	14.4	21.8	0.5	0.1	5.0	43.8	10.0	40.0	1
	17c	162	0.0	0.2	3.9	14.2	0.0	5.0	5.0	0.0	-1

Notes: Indicators shaded in red have absolute skewness greater than 2.0 and kurtosis greater than 3.5 and/or data coverage below 80%. The list of indicators is provided in Annex I.

* Only for the 51 High Income & OECD countries included in the country list. ** Excluding the High Income & OECD countries.

Source: European Commission's Joint Research Centre, 2019.

In general, the data coverage for the indicators included in the index is good, covering at least 80% both at indicator and country level. Countries are included if data availability is at least 80% at index level, however this is not the case at goal level where in some SDGs there are countries which have no indicator data at all. In these cases, the developers impute the missing value using the regional average score in the specific goal. For example, Afghanistan misses both indicators in SDG1 (No poverty) so the SDG1 score that it gets is the regional score for East Europe & Central Asia. This implies primarily to SDG10, but also to SDG1, SDG4, SDG14, SDG15 and SDG17. SDG14 is a particular case since the countries that miss data are the landlocked countries. The countries that miss more than 55% of indicators on a specific goal (excluding SDG14) are listed in Table 3.

This is a fact that needs to be highlighted so that conclusions are carefully drawn for these countries, since the results can be reflecting more a regional average than the particular situation of the country. Therefore, the JRC recommends for the following editions of the index to increase the number of indicators in these SDGs and/or focus specifically on aforementioned countries trying to find alternative data sources.

Table 3. Countries missing more than 55% of indicators at goal level in the SDG Index.

SDG1	SDG4	SDG10	SDG15	SDG17
Afghanistan	Australia	Afghanistan	Jordan	Cuba
Bahrain	Austria	Bahrain		Kuwait
Cuba	Bosnia and Herzegovina	Belize		Montenegro
Kuwait	Canada	Cuba		Trinidad and Tobago
Oman	Czech Republic	Guyana		
Qatar	Gabon	Kuwait		
Saudi Arabia	Haiti	New Zealand		
Syrian Arab Republic	Netherlands	Oman		
United Arab Emirates	New Zealand	Qatar		
Yemen, Rep.	Slovak Republic	Saudi Arabia		
Zimbabwe	Turkmenistan	Singapore		
	United Kingdom	Suriname		
	United States	Trinidad and Tobago		
		Turkmenistan		

Source: European Commission's Joint Research Centre, 2019.

Besides the use of regional average values for imputing data for the cases above, there are also around eight indicators with poor data coverage for which data is imputed on a case-by-case basis [3]. The approaches used to impute the missing data are described on the SDG Index detailed methodological paper, while the imputed data can be clearly identified in the SDG Index dataset. These are important aspects contributing to increase the transparency of the SDG Index.

2.3 Identification and treatment of outliers

Potentially problematic indicators that could bias the overall index results were identified on the basis of two measures related to the shape of the distributions: the skewness and kurtosis. A practical rule used by the JRC [6] is that an indicator should be considered for treatment if it has an absolute skewness greater than 2.0 and kurtosis greater than 3.5.

Based on this rule, Table 2 shows that initially there are 18 potentially problematic indicators in the raw dataset which would require greater attention because of their skewed distributions. After the lower and upper bound setting by the developers this number was reduced. However, there are nine indicators which remain very skewed: HIV infections (3e), Imported groundwater depletion (6d), CO₂ emissions from fuel combustion (7c), Fatal Accidents embodied in imports (8e), People affected by climate-related disasters (13c), CO₂ emissions embodied in fossil fuel exports (13d), Commodity-driven deforestation (15d), Homicides (16a), Weapons exports (16h) and Tax Haven Score (17c). As suggested by the JRC, the index developers applied different techniques to improve the distributions, such as logarithmic transformations, but no major improvements were observed. Due to the policy relevance of these indicators identified by the developers, they have decided to keep them in the framework, however for completeness; the effect of removing these indicators is investigated in the uncertainty analysis in Section 3.

2.4 Normalisation

As mentioned on section 2.2, the developers used boundaries on the lower and upper bounds of the scale. The indicators' values are normalised using the min-max normalisation method on a scale of 0 to 100 using as minimum and maximum values the pre-set bounds. The rescaling equation ensured that all rescaled variables were expressed as ascending variables (i.e. higher values denoted better performance). In this way, the rescaled data became easy to communicate to a wider public and to compare across all indicators.

2.5 Weighting and aggregation

The SDG Index is calculated using equal weighting for the underlying components. At goal level, this is justified by the fact that all SDGs are considered as having equal importance as part of the 2030 Agenda. At the indicator level, equal weighting was retained because all alternatives were considered as being less satisfactory. However, assigning equal weights to the indicators and goals do not necessarily guarantee an equal contribution of the indicators or goals to the SDG Index [6] [7]. For example, considering that goals are measured using an uneven number of indicators, the 14 global indicators under SDG3 are effectively weighted less in the overall aggregation than the single indicator used to measure SDG 10.

Regarding the aggregation formula, the arithmetic average is used at all levels to build the SDG Index; at the first aggregation level (from indicators to goals) and at the second and last aggregation level (from goals to the overall index). This means that the overall index is calculated as the arithmetic average over the 17 SDGs. While arithmetic averages are easy to interpret, they also allow perfect compensability between the variables, whereby a high score on one variable can fully offset low scores in other variables. This may not necessarily fit with the concept of sustainable development where having a high social sustainability should not come at the cost of low environmental sustainability, although this is often observed in practice - see the following section. The geometric average is an alternative aggregation method which is non-compensatory and fits with the view that scores in different dimensions of sustainability should not compensate one another. The

impacts of the aggregation formula as well as of the weighting scheme in the index results will be discussed thoroughly in section 3.

2.6 Cross-correlation analysis

The statistical coherence of the SDG Index should be considered a necessary, though not necessarily sufficient, condition for a sound index. Given that the present statistical analysis is mostly based on correlations, the correspondence of the SDG Index to a real world phenomenon needs to be critically addressed because “correlations do not necessarily represent the real influence of the individual indicators on the phenomenon being measured” [6]. This relies on the combination of statistical and conceptual soundness. The cross-correlation analysis is used to address to what extent the data support the conceptual framework. The 1% significance level is used to determine whether the correlation between two variables is statistically significant.

In the ideal case, there should be positive significant correlations within every level of the index, i.e. each indicator positively correlated with its goal and the index as well as each goal correlated with the index. This effectively ensures that the overall index scores adequately reflect the underlying indicator values. Redundancy should be avoided in the framework because if two indicators are collinear, this amounts to double-counting (and therefore over-weighting) the same phenomenon. It also increases the complexity, which is contrary to good practices of data modelling, in which the simplest model that explains the data (or phenomenon) is preferable (Occam’s Razor).

A detailed analysis of the correlation within and across goals confirms that most of the indicators are more correlated to their own goal than to any other goal. A few exceptions were found, but as the SDG Index conceptual framework is limited by the fixed structure of the UN SDG official framework [8], those indicators cannot be simply transferred from one goal to another, as acknowledged by the index developers. Overall, correlations within each goal are significant and positive, but there are a few indicators which would require greater attention due to their negative correlation with other indicators and with the goal.

Table 4 shows the correlation between indicators, their respective goal and the overall index. Some indicators are negatively correlated with their respective goal and/or with the index (highlighted in red), typically as a result of negative correlations with other indicators. Other indicators are highly collinear (i.e. Pearson correlation coefficients greater than 0.92) with their respective goal (highlighted in blue).

Table 4. Correlations between the indicators, their respective goal and the overall index.

Indicator id	Respective SDG	Index	Indicator id	Respective SDG	Index	Indicator id	Respective SDG	Index
1a	0.95	0.79	5d	0.65	0.33	12f	0.77	-0.35
1b	0.98	0.89	6a	0.79	0.83	13a	0.70	-0.47
2a	0.66	0.78	6b	0.76	0.86	13b	0.56	-0.16
2b	0.71	0.85	6c	0.25	-0.06	13c	0.46	0.25
2c	0.69	0.64	6d	0.16	-0.06	13d	0.69	-0.08
2d	-0.24	-0.54	6e	0.70	0.69	14a	0.55	0.34
2e	0.68	0.68	7a	0.95	0.83	14b	0.37	0.36
2f	0.55	0.41	7b	0.94	0.84	14c	0.50	-0.26
2g	-0.32	-0.74	7c	0.51	0.35	14d	0.50	-0.48
3a	0.89	0.84	8a	0.71	0.65	15a	0.78	0.25
3b	0.93	0.88	8b	0.64	0.58	15b	0.81	0.22
3c	0.94	0.89	8c	0.74	0.77	15c	0.52	0.10
3d	0.70	0.59	8d	0.44	0.08	15d	0.36	0.35
3e	0.47	0.38	8e	-0.14	-0.34	15e	0.22	-0.46
3f	0.64	0.57	9a	0.88	0.86	16a	0.49	0.31
3g	0.89	0.84	9b	0.84	0.79	16b	0.61	0.46
3h	0.79	0.77	9c	0.92	0.70	16c	0.72	0.50
3i	0.97	0.91	9d	0.89	0.63	16d	0.76	0.58
3j	0.83	0.76	9e	0.89	0.68	16e	0.68	0.73
3k	0.79	0.76	9f	0.88	0.66	16f	0.83	0.69
3l	0.62	0.59	10a	1.00	0.41	16g	0.75	0.80
3m	0.94	0.91	11a	0.73	0.51	16h	-0.32	-0.43
3n	0.79	0.77	11b	0.78	0.68	16i	0.40	0.34
4a	0.84	0.70	11c	0.60	0.45	17a	0.58	0.62
4c	0.92	0.83	12a	0.73	-0.48	17b1	0.69	0.30
4b	0.92	0.80	12b	0.92	-0.79	17b2	0.91	0.48
5a	0.74	0.63	12c	0.51	-0.34	17c	0.34	-0.23
5b	0.71	0.71	12d	0.73	-0.52			
5c	0.45	-0.01	12e	0.85	-0.53			

Notes: Numbers represent the Pearson correlation coefficients between each indicator and the corresponding goal as well as between each indicator and the overall index. Correlations that are not significant at the significance level of $\alpha = 0.01$ are highlighted in grey (critical value of 0.202). Very high correlations (i.e. Pearson correlation coefficients greater than 0.92) are highlighted in blue and negative correlations in red.

Source: European Commission's Joint Research Centre, 2019.

Table 5 summarises the correlation coefficients between goals as well as between each goal and the overall index. Values greater than 0.70 are desirable as they imply that the index captures at least 50% ($\approx 0.70 \times 0.70$) of the variation in the underlying goals and vice-versa. This is the case for 11 out of 17 SDGs: from SDG1 to SDG9, SDG11 and SDG16. SDG3 shows a very high correlation (Pearson correlation coefficient 0.93) which may suggest redundancy. SDG10 and SDG17 have lower correlation coefficients but still significant, suggesting that their importance is lower than that of the other goals. With respect to the remaining goals, SDG14 and SDG15 show no significant correlation with the overall index, while SDG12 and SDG13 present a negative relationship with the index. In practice, this means that the highest scoring countries on the SDG Index are having some of the lowest scores in SDG12 and SDG13, and vice versa, which can give the impression

that high-scoring countries score highly in all goals. This seems to be an unavoidable reality in which environmental sustainability goes somewhat contrary to social sustainability, and motivates the possibility of using a non-compensatory geometric mean, as discussed earlier. In order to address this issue, a possible revision of the indicators which are not significantly correlated or negatively correlated under each of these four goals could be considered by the developers, particularly in the case where official SDGs indicators are not adopted. In any case, the important is that this disparity between the SDG Index scores and SDG12 and SDG13 should be made clear in the conclusions of the SDG Index, possibly by presenting index scores additionally with these two goals. These issues are further discussed in Section 4.

Table 5. Correlations between the goals and SDG Index.

SDG	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	Index
1	1.00																	
2	0.49	1.00																
3	0.84	0.64	1.00															
4	0.77	0.61	0.84	1.00														
5	0.35	0.54	0.59	0.61	1.00													
6	0.69	0.66	0.81	0.73	0.68	1.00												
7	0.88	0.50	0.85	0.81	0.46	0.71	1.00											
8	0.50	0.60	0.68	0.62	0.59	0.63	0.51	1.00										
9	0.66	0.66	0.82	0.67	0.59	0.75	0.68	0.63	1.00									
10	0.36	0.29	0.36	0.17	0.01	0.21	0.19	0.24	0.38	1.00								
11	0.54	0.46	0.68	0.66	0.64	0.69	0.59	0.53	0.55	0.10	1.00							
12	-0.59	-0.53	-0.76	-0.59	-0.52	-0.67	-0.60	-0.46	-0.86	-0.32	-0.50	1.00						
13	-0.28	-0.17	-0.33	-0.32	-0.18	-0.19	-0.27	-0.10	-0.32	-0.05	-0.13	0.50	1.00					
14	-0.17	-0.01	-0.11	-0.10	0.09	-0.04	-0.13	0.06	-0.05	-0.19	-0.04	0.04	0.02	1.00				
15	-0.09	0.15	-0.02	-0.03	0.17	0.12	-0.05	0.14	0.09	0.01	-0.01	-0.02	0.22	0.24	1.00			
16	0.64	0.59	0.81	0.67	0.50	0.65	0.60	0.58	0.78	0.43	0.63	-0.72	-0.33	-0.11	0.04	1.00		
17	0.19	0.07	0.21	0.22	0.14	0.12	0.29	-0.03	0.11	0.01	0.16	-0.12	-0.35	-0.02	-0.08	0.14	1.00	
Index	0.84	0.71	0.93	0.86	0.67	0.86	0.86	0.73	0.83	0.40	0.73	-0.68	-0.20	-0.01	0.14	0.79	0.24	1.00

Notes: Numbers represent the Pearson correlation coefficients between the SDG Index goals and the overall index. Correlations that are not significant at the significance level of $\alpha = 0.01$ are highlighted in grey (critical value of 0.202). Very high correlations (i.e. Pearson correlation coefficients greater than 0.92) are highlighted in blue and negative correlations in red.

Source: European Commission's Joint Research Centre, 2019.

2.7 Principal components analysis

Principal components analysis (PCA) [9] [10] explores the correlation of all the indicators simultaneously, highlighting, if present, some common trends that describe a common concept among the indicators. It is here used to assess to what extent the conceptual framework of the SDG Index is confirmed by statistical approaches.

The results of the PCA performed to the total group of 85 indicators show that there are 17 principal components with eigenvalues greater than 1 that explain almost 80% of the total variance (Table 6). That suggests the presence of several drivers among the indicators and is correctly accommodated by the use of the 17 goals as an intermediate step towards the creation of the overall score.

Table 6 - Results of the Principal Components Analysis on the 85 indicators.

	eigenvalue	% of variance	cumulative % of variance
PC1	33.38	39.27	39.27
PC2	6.39	7.51	46.78
PC3	4.57	5.38	52.16
PC4	3.37	3.96	56.12
PC5	2.54	2.99	59.11
PC6	2.18	2.56	61.68
PC7	1.99	2.34	64.02
PC8	1.82	2.14	66.16
PC9	1.70	2.00	68.16
PC10	1.51	1.78	69.94
PC11	1.44	1.69	71.63
PC12	1.26	1.48	73.11
PC13	1.16	1.37	74.48
PC14	1.13	1.33	75.82
PC15	1.05	1.23	77.05
PC16	1.04	1.22	78.27
PC17	0.96	1.13	79.39
PC18	0.87	1.02	80.41
PC19	0.86	1.01	81.42
PC20	0.81	0.95	82.37

Results shown for the first 20 out of 85 principal components (PC).

Source: European Commission's Joint Research Centre, 2019.

At a second step, PCA is performed to the 17 goals that, after aggregation, form the overall SDG Index score. Ideally, it is expected to have one principal component (PC) explaining at least 70%-80% of the total variance in order to claim that there is a single latent phenomenon behind the data. This is not the case in the SDG Index, as the results show that there are four principal components that explain around 70% of the variance. From the Table 7, the presence of a major driver is evident; the first component explains 50% of the variance, although, still, there are three other components that are explaining enough amount (eigenvalues ≥ 1).

Table 7 - Results of the Principal Components Analysis on the 17 goals.

	eigenvalue	% of variance	cumulative % of variance
PC1	8.37	49.26	49.26
PC2	1.67	9.82	59.08
PC3	1.32	7.76	66.84
PC4	1.07	6.32	73.16
PC5	0.84	4.96	78.12
PC6	0.71	4.19	82.31
PC7	0.63	3.68	85.99
PC8	0.53	3.09	89.08
PC9	0.41	2.41	91.49
PC10	0.35	2.04	93.53
PC11	0.31	1.84	95.38
PC12	0.23	1.37	96.74
PC13	0.17	1.01	97.75
PC14	0.15	0.87	98.62
PC15	0.09	0.55	99.18
PC16	0.08	0.48	99.66
PC17	0.06	0.34	100.00

Source: European Commission's Joint Research Centre, 2019.

Figure 1 shows in more detail that most goals form a group on the right quadrant, which is explained by the first principal component. Then, it is possible to observe that goal 12 forms a second group opposite to the first (as suggested by the negative correlations). In addition, a third group comprises goals 13, 14 and 15 orthogonal to the first two groups and a fourth group includes goal 17, more close to the first one.

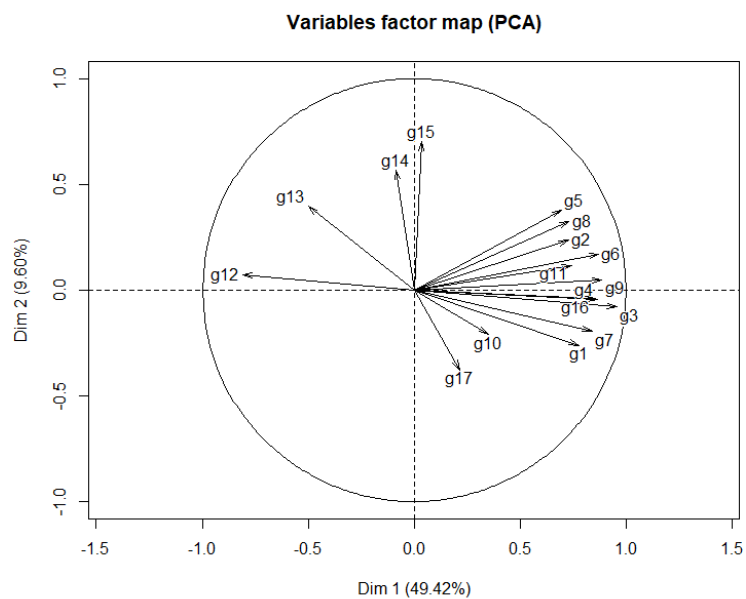


Figure 1 – Factor map of the 17 goals of the SDG Index.

Source: European Commission's Joint Research Centre, 2019.

3 Impact of modelling assumptions on the SDG Index results

The development of a composite indicator, like any model, involves assumptions and subjective decisions. This section aims to test the impact of varying some of these assumptions within a range of plausible alternatives in an *uncertainty analysis*. The objective is therefore to try to quantify the uncertainty in the ranks of the SDG Index, which can demonstrate the extent to which countries can be differentiated by their SDG Index scores.

Although many assumptions made in the development of the SDG Index could be examined, three particular assumptions were examined in this uncertainty analysis (see Table 8). These were chosen as plausible alternative pathways in the construction of the SDG Index, which can be relatively easily investigated.

Table 8. Conceptual framework of the SDG Index.

Assumption	Alternatives
1. Indicator set	Full set Reduced set
2. Aggregation method (pillar level)	Arithmetic average Geometric average
3. Weights (pillar level)	Randomly varied +/-25% from nominal values

The first is the inclusion of indicators: in the present audit, a number of statistically “problematic” indicators were identified, which have issues in terms of skewness and correlation (see section 2.3). For conceptual and communication reasons, these indicators were retained in the final index, but the effect is tested here of removing all of these indicators simultaneously, resulting in a “reduced set” of indicators which can be viewed as an alternative approach to building the index. The second assumption which is varied is the aggregation method. In the SDG Index, the goal scores are aggregated into a single score using an arithmetic average. An alternative approach would be to use the geometric average, which is *non-compensatory*, and represents the idea that high scores in one goal should not compensate low scores in another, which is an alternative way to look at sustainable development. Finally, nominal weights assigned at the goal level are all equal. The effect of randomly varying these weights by +/-25% is investigated, to check modest variations in the importance of individual goals.

To investigate the impact of varying these assumptions, a Monte Carlo experiment was performed, which involved re-building the SDG Index 4000 times, each time with a randomly-selected combination of assumptions 1-3. The overall results are shown in Figure 2.

The uncertainty in the rankings, given the assumptions tested, is mostly quite modest, but some countries show particular sensitivity to changes. About 40% of countries have 90% confidence intervals² of ten places or less, with 10% having confidence intervals of five places or fewer. The average confidence interval size is about 13 rank places, however, this is over 162 countries in total, so does not represent a very large uncertainty in this context. A small number of countries have wider confidence intervals (14% have intervals wider than 20 places), with Singapore in particular having an interval of 57 places. The ranking of Bosnia and Herzegovina is also more uncertain, with a confidence interval of 49 places. These stand-out cases are likely due to particularly uneven scores across indicators

² A 90% confidence interval means that, given the uncertainties tested, the rank falls within this interval with 90% probability.

and goals, which mean that changes in the weighting and aggregation scheme have a greater impact.

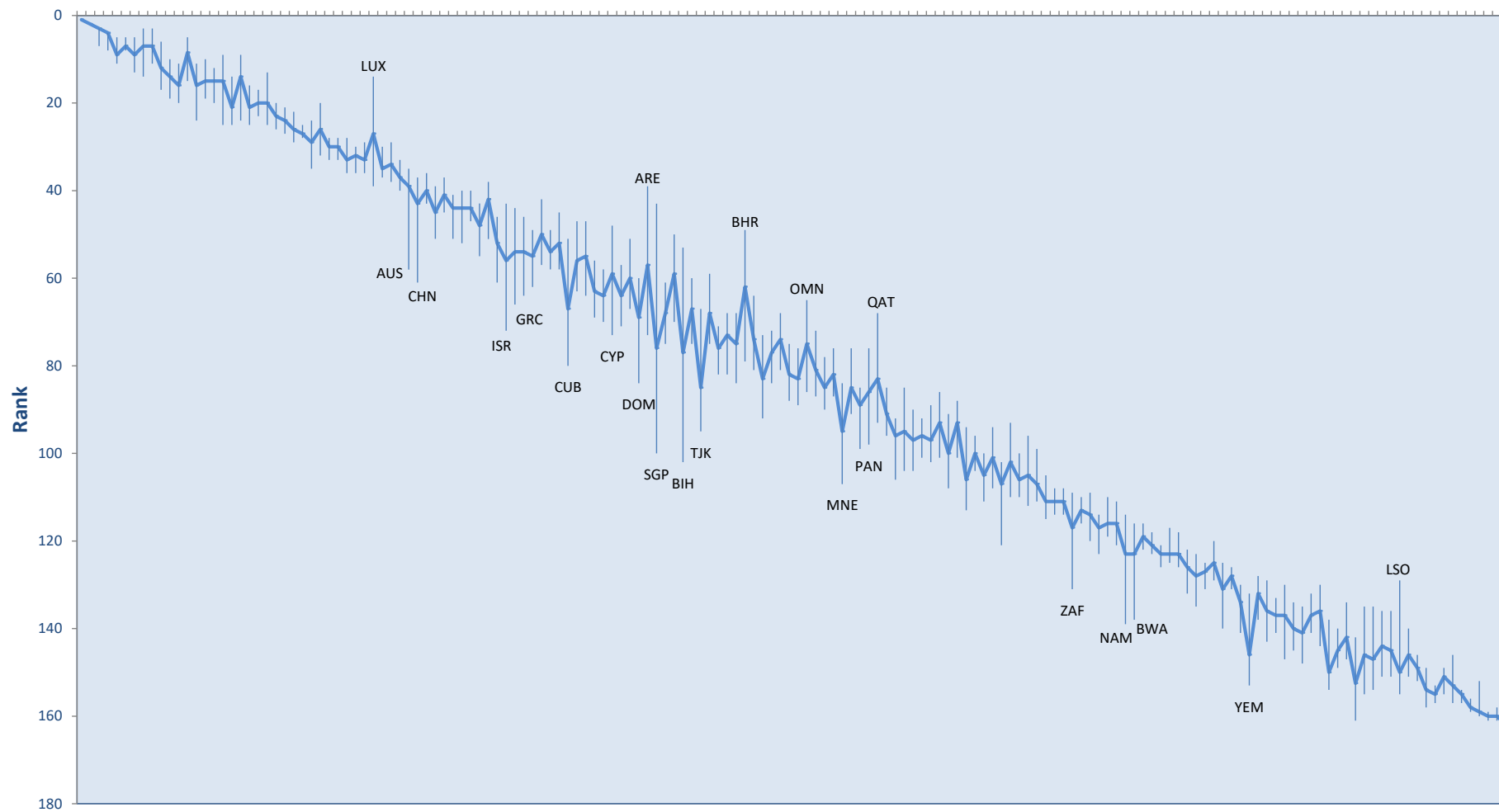


Figure 2 – 90% confidence intervals of ranks in descending order of nominal rank. Selected countries with confidence intervals wider than 20 places are labelled.

Source: European Commission's Joint Research Centre, 2019.

The overall picture is that the ranks of the SDG Index are fairly robust, and country ranks can be stated to within around 13 places of precision, although some countries are especially sensitive to the assumptions made. This information should be used to guide the kind of conclusions that can be drawn from the index. For example, differences of two or three places between countries cannot be taken as “significant”, whereas differences of 10 places upwards can show a meaningful difference. One can also observe from Figure 2 that the confidence intervals are generally wider for mid-ranking countries, and narrower for top and bottom-ranking countries.

The Monte Carlo results can also give an idea of sensitivity to the various assumptions. Figure 3 shows the median ranks of the SDG Index for simulations with the full set of indicators against those with the reduced set, and arithmetic against geometric mean. This gives an idea of sensitivity of the rankings to these assumptions. Both plots show a noticeable but fairly limited scatter, which implies that the assumptions are both contributing fairly equally to the uncertainty, although the alternative geometric mean assumption causes greater extreme rank shifts.

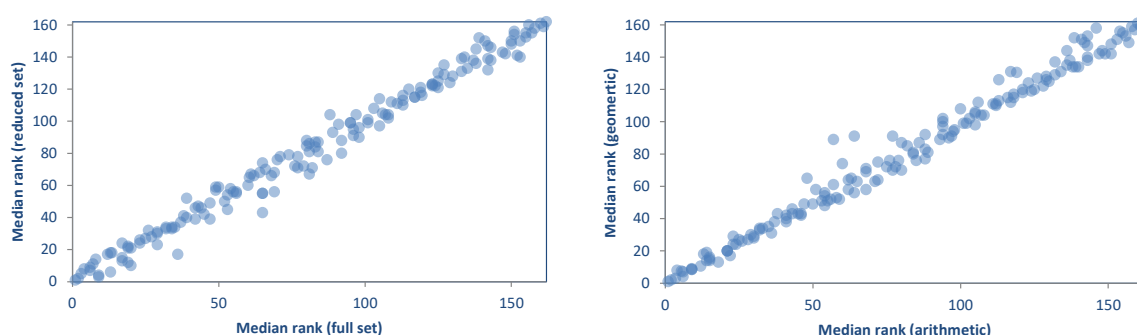


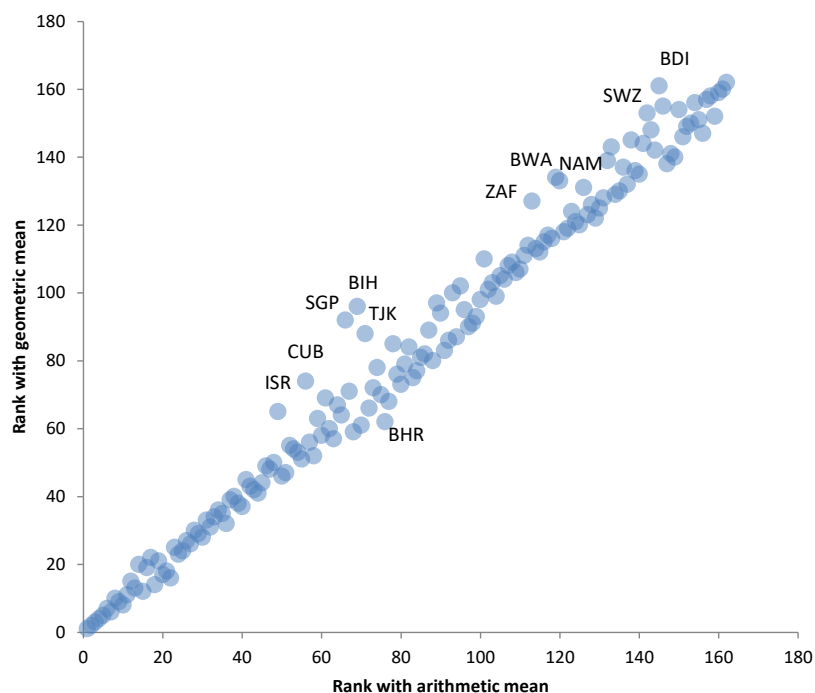
Figure 3 – Median ranks of SDG Index with full set of indicators against reduced set (left), and arithmetic mean against geometric mean (right).

Source: European Commission’s Joint Research Centre, 2019.

To delve slightly further into the possibility of using a geometric average, Figure 4 shows the nominal ranks of the SDG Index (i.e. the default modelling assumptions used by the developers and featured in the final index) plotted against the nominal ranks with a geometric mean applied at the goal level. This is different from Figure 3 in that the uncertainty in the other assumptions is not considered. The results show that the impact of changing to a geometric mean is fairly limited for many countries, with an average rank shift of around four places. However, some countries do shift by a significant amount, including Bosnia (-27), Singapore (-26), and Cuba (-18).

The JRC recommends to weigh up the possibility of using a geometric average: it may better reflect the non-compensatory nature of sustainable development, but is more difficult to communicate to stakeholders and comes with a fairly small change in rankings for most countries. This possibility might be reflected on by the developers in future versions of the SDG Index.

Figure 4 – Nominal ranks with arithmetic mean vs geometric mean at goal level. Selected countries with a large rank change are labelled.



Source: European Commission's Joint Research Centre, 2019.

The overall implications of the uncertainty analysis are that the uncertainty in the rankings is manageable, and allows meaningful conclusions to be drawn from the index, although both the aggregation method and the set of indicators do cause a modest contribution to the uncertainty. The full rankings, with confidence intervals, can be found in Annex II.

4 Communication on the SDG Index results

It is important to note that the SDG Index can be used as an overall aggregate score, but should also serve as an access point to the underlying goals and indicators. The JRC recommends the developers to derive more policy narratives and conclusions by delving into the individual goals (i.e. first level of aggregation), rather than focusing exclusively on the SDG Index score. The index score can indeed reveal patterns which do not directly emerge by looking at the 17 goals separately, but an analysis at goal level can provide more additional insights.

In fact, a detailed analysis of the countries' ranking positions at SDG Index level and at each goal level (Table 9) reveals that for 56% or more of the 162 countries included, the SDG Index ranking and any of the 17 goals rankings differ by 10 positions or more. The results suggest that the SDG Index ranking highlights aspects of countries' efforts towards sustainable development that do not emerge by looking into each one of the goals separately. But at the same time, this result points to the value of examining individual goals on their own merit in order to identify which goals are driving a country's performance, having into account that the overall index score allows full compensability. In particular, SDG10, SDG12, SDG13, SDG14, SDG15 and SDG17 have more than 80% of countries that differ by more than 10 positions from the overall SDG Index ranking. On the other hand, SDG3 which presents the highest correlation with the overall index has the lower number of countries with a shift of more than 10 positions (56%).

Table 9 – Distribution of differences between goals and SDG Index rankings.

Shifts with the respect to SDG Index	SDG1	SDG2	SDG3	SDG4	SDG5	SDG6	SDG7	SDG8	SDG9	SDG10	SDG11	SDG12	SDG13	SDG14	SDG15	SDG16	SDG17
0 positions	2%	1%	3%	1%	1%	2%	3%	1%	4%	2%	1%	1%	0%	0%	1%	4%	1%
Less than 5 positions	17%	9%	20%	15%	9%	16%	19%	12%	22%	6%	17%	4%	3%	4%	4%	20%	7%
5 to 10 positions	14%	12%	24%	14%	12%	20%	18%	9%	15%	8%	8%	5%	3%	6%	7%	12%	12%
More than 10 positions	69%	78%	56%	71%	78%	64%	64%	79%	64%	86%	75%	91%	94%	91%	88%	68%	81%
11 to 20 positions	27%	23%	27%	31%	21%	27%	29%	25%	28%	19%	22%	10%	12%	11%	13%	21%	12%
21 to 30 positions	19%	19%	15%	15%	20%	19%	12%	17%	15%	9%	17%	7%	3%	7%	17%	16%	10%
More than 30 positions	23%	36%	14%	25%	38%	18%	22%	37%	20%	59%	36%	73%	78%	73%	59%	31%	59%

Source: European Commission's Joint Research Centre, 2019.

Countries ranking first on the aggregated SDG Index can have significantly lower positions on individual goals. This happens due to the presence of significant negative correlations between SDG12 and SDG13 with any of the other goals in the SDG Index framework (see section 2.6).

While there is a clear positive association between the SDG Index and most of the underlying goals, the same does not hold true for SDG12 and SDG13. From a statistical point, the negative relationship between goals is a sign of trade-off, whereby some countries that have poor performance on SDG12 and SDG13 have good performance on all the other goals and vice-versa.

Figure 5 confirms the negative relationship between these two goals and the overall index score. The top five countries are ranked among the bottom positions of SDG12 and SDG13. For example, Denmark tops the list on the SDG Index, but is on the 143th position on the SDG12 ranking. On the other direction, Central African Republic which is at the bottom of the SDG Index gets the second best position on SDG13.

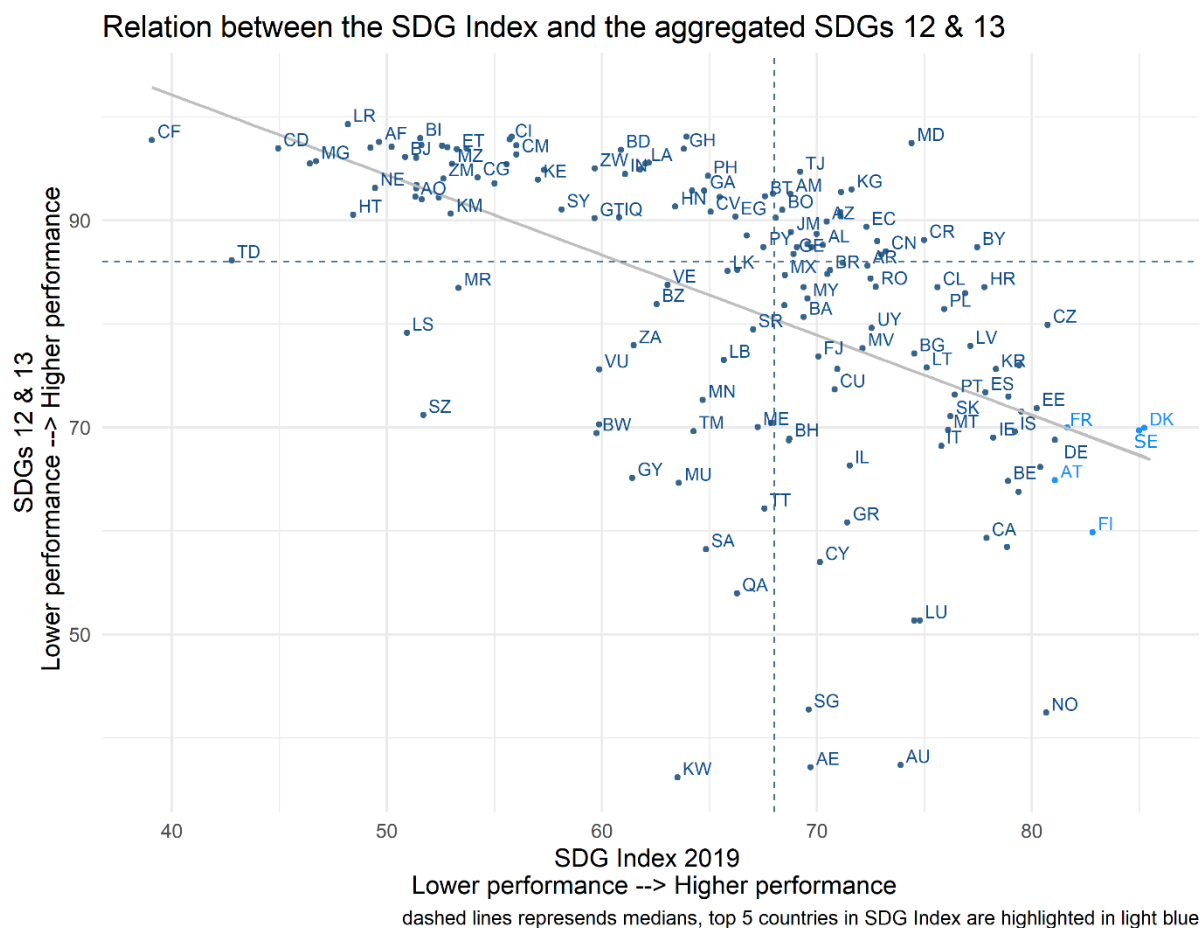


Figure 5 - Relation between the goals 12, 13 combined, and the SDG Index.

Source: European Commission's Joint Research Centre, 2019.

In addition to the SDG Dashboards where one perceives at a glance in which goals a country is scoring better or worse as well as which goals present the greatest challenges, the JRC would recommend to further explore how the statistical associations between goals could be used to inform SDGs policies at global and national levels.

For instance, if the 17 SDGs are grouped into two groups: the environmental group on one side (SDG12, SDG13, SDG14, SDG15) and all the other goals on the other side (SDG1, SDG2, SDG3, SDG4, SDG5, SDG6, SDG7, SDG10, SDG11, SDG16, SDG17), one could look at the countries located on the top right quadrant as the ones which have more balanced profiles in terms of achieving both highest environmental and socio-economic performance (Figure 6). This would be a complementary view to the index rankings.

5 Conclusions

The JRC statistical audit delves into the extensive work carried out by the developers of the SDG Index with the aim of suggesting improvements in terms of data characteristics, structure and methods used. The analysis aims to ensure the transparency of the SDG Index methodology and the reliability of the results. The present audit was preceded by a JRC assessment on the 2018 edition, from which some suggestions related to data quality issues were taken into account by the developers in the 2019 edition.

This report focused first on the assessment of the statistical coherence of the SDG Index by carrying out a multilevel analysis of the correlations within and across the indicators and goals. It was then followed by an assessment of the impact of key modelling assumption on the SDG index ranking.

The methodology to calculate the SDG Index adopted by the developers included data checking for outliers; normalisation using the min-max method in 1-100 scale (100 the best score) including lower and upper bound setting, and; aggregation at all levels (i.e. from indicators to goals and from goals to the overall index) by simple arithmetic average and equal weighting.

The main challenge on the construction of the SDG Index lays on the inverted relationship between socio-economic goals and environmental ones, in particular SDG12 (responsible consumption and production) and SDG13 (climate action). Also, SDG 14 (life below water) and SDG 15 (life on land) show no significant association with the SDG Index. The negative relationship between goals is a sign of trade-off, whereby some countries that have poor performance on SDG12 and SDG13 have good performance on all the other goals and vice-versa. Upon these considerations, the JRC recommendation would be to focus on a complementary analysis on the relationships between goals and to consider the option of using the geometric average instead of the arithmetic average. The geometric average could serve as an alternative aggregation method that is non-compensatory and fits with the view that scores in different dimensions of sustainable development should not compensate one another.

The uncertainty and sensitivity analyses carried out confirm that the uncertainty is manageable and allows meaningful conclusions to be drawn from the SDG Index. Nevertheless, both the aggregation method and the set of indicators do cause a modest contribution to the uncertainty. A suggestion would be to guide the conclusions that can be drawn from the SDG Index using the following information: differences of two or three places between countries cannot be taken as “significant”, whereas differences of 10 places can show a meaningful difference.

All things considered, the SDG Index is a noteworthy effort of synthesizing the 17 adopted SDGs into a single figure. Overall, the ranks of the SDG Index are fairly robust. The index is anchored on the 2030 Agenda for Sustainable Development adopted by all UN member states and rigorously follows the same structure of 17 goals. The fact that the goals are universal and highly diverse in nature makes the work of aggregating into a single number quite challenging from a statistical point of view. The index is also complemented by dashboards, which are a very communicative and neat way to show the performance of countries at individual goal level. The SDG Index proposes a first-of-its-kind composite measure to track progress on SDGs at national and global level, but it is fundamental that communication of its results is accompanied by a deep understanding of its underlying components and the relationships between them.

References

- [1] E. Papadimitriou, A. R. Neves, and W. Becker, "JRC Statistical Audit of the Sustainable Development Goals Index and Dashboards (Excel spreadsheet)." 2019.
- [2] Sachs; J.; Schmidt-Traub; G.; Kroll; C.; Lafortune; Fuller, "SDG Index and Dashboards Report 2018: Global Responsibilities," New York, 2018.
- [3] G. Lafortune, G. Fuller, J. Moreno, G. Schmidt-traub, and C. Kroll, "SDG Index and Dashboards - Detailed Methodological paper," 2018.
- [4] E. Papadimitriou, A. R. Neves, and W. Becker, "Joint Research Centre Statistical Pre-Audit of the 2018 Sustainable Development Goals Index and Dashboards," 2019.
- [5] United Nations, "Transforming Our World: The 2030 Agenda for Sustainable Development, A/RES/70/1," vol. 16301, no. October. United Nations General Assembly, pp. 1–35, 2015.
- [6] OECD and JRC, *Handbook on Constructing Composite Indicators - Methodology and User Guide*. OECD Publications, 2008.
- [7] W. Becker, M. Saisana, P. Paruolo, and I. Vandecasteele, "Weights and importance in composite indicators: Closing the gap," vol. 80, no. May, pp. 12–22, 2017.
- [8] Inter-Agency and Expert Group on SDG Indicators (IAEG-SDGs), "Final list of proposed Sustainable Development Goal indicators," 2016.
- [9] F. B. Bryant and P. R. Yarnold, "Principal-components analysis and exploratory and confirmatory factor analysis," in *Reading and understanding multivariate statistics*, L. G. G. & P. R. Yarnold, Ed. Washington, DC, US: American Psychological Association., 1995, pp. 99–136.
- [10] R. A. Johnson and D. W. Wichern, *Applied multivariate statistical analysis*, 3rd. ed. Prentice-Hall: Englewood Cliffs (N.J.), 1992.

Annex I – List of indicators included in the 2019 SDG Index

Goal	ID	Indicator
SDG1	1a	Poverty headcount ratio at \$1.90/day (% population)
	1b	Poverty headcount ratio at \$3.20/day (% population)
SDG2	2a	Prevalence of undernourishment (% population)
	2b	Prevalence of stunting (low height-for-age) in children under 5 years of age (%)
	2c	Prevalence of wasting in children under 5 years of age (%)
	2d	Prevalence of obesity, BMI \geq 30 (% adult population)
	2e	Cereal yield (t/ha)
	2f	Sustainable Nitrogen Management Index
	2g	Human Tropic Level (best 2 - 3 worst)
SDG3	3a	Maternal mortality rate (per 100,000 live births)
	3b	Neonatal mortality rate (per 1,000 live births)
	3c	Mortality rate, under-5 (per 1,000 live births)
	3d	Incidence of tuberculosis (per 100,000 population)
	3e	New HIV infections (per 1,000)
	3f	Age-standardised death rate due to cardiovascular disease, cancer, diabetes, and chronic respiratory disease in populations age 30–70 years (per 100,000 population)
	3g	Age-standardised death rate attributable to household air pollution and ambient air pollution (per 100,000 population)
	3h	Traffic deaths rate (per 100,000 population)
	3i	Life Expectancy at birth (years)
	3j	Adolescent fertility rate (births per 1,000 women ages 15-19)
	3k	Births attended by skilled health personnel (%)
	3l	Percentage of surviving infants who received 2 WHO-recommended vaccines (%)
	3m	Universal Health Coverage Tracer Index (0-100)
	3n	Subjective Wellbeing (average ladder score, 0-10)
SDG4	4a	Net primary enrolment rate (%)
	4b	Literacy rate of 15-24 year olds, both sexes (%)
	4c	Lower secondary completion rate (%)
SDG5	5a	Demand for family planning satisfied by modern methods (% women married or in unions, ages 15-49)
	5b	Ratio of female to male mean years of schooling of population age 25 and above
	5c	Ratio of female to male labour force participation rate
	5d	Seats held by women in national parliaments (%)
SDG6	6a	Population using at least basic drinking water services (%)
	6b	Population using at least basic sanitation services (%)
	6c	Freshwater withdrawal as % total renewable water resources
	6d	Imported groundwater depletion (m3/year/capita)
	6e	Percentage of anthropogenic wastewater that receives treatment (%)
SDG7	7a	Access to electricity (% population)
	7b	Access to clean fuels & technology for cooking (% population)
	7c	CO2 emissions from fuel combustion / electricity output (MtCO2/TWh)

Goal	ID	Indicator
SDG8	8a	Adjusted Growth (%)
	8b	Prevalence of Modern Slavery (victims per 1,000 pop)
	8c	Adults (15 years and older) with an account at a bank or other financial institution or with a mobile-money-service provider (%)
	8d	Unemployment rate (% total labor force)
	8e	Fatal Accidents embodied in imports (fatal accidents per 100,000)
SDG9	9a	Population using the internet (%)
	9b	Mobile broadband subscriptions (per 100 inhabitants)
	9c	Logistics performance index: Quality of trade and transport-related infrastructure (1=low to 5=high)
	9d	The Times Higher Education Universities Ranking, Average score of top 3 universities (0-100)
	9e	Number of scientific and technical journal articles (per 1,000 population)
	9f	Research and development expenditure (% GDP)
SDG10	10a	Gini Coefficient adjusted for top income (1-100)
SDG11	11a	Annual mean concentration of particulate matter of less than 2.5 microns of diameter (PM2.5) (µg/m3)
	11b	Improved water source, piped (% urban population with access)
	11c	Satisfaction with public transport (%)
SDG12	12a	Municipal Solid Waste (kg/year/capita)
	12b	E-waste generated (kg/capita)
	12c	Production-based SO2 emissions (kg/capita)
	12d	Imported SO2 emissions (kg/capita)
	12e	Nitrogen production footprint (kg/capita)
	12f	Net imported emissions of reactive nitrogen (kg/capita)
SDG13	13a	Energy-related CO2 emissions per capita (tCO2/capita)
	13b	Imported CO2 emissions, technology-adjusted (tCO2/capita)
	13c	People affected by climate-related disasters (per 100,000 population)
	13d	CO2 emissions embodied in fossil fuel exports (kg/capita)
SDG14	14a	Mean area that is protected in marine sites important to biodiversity (%)
	14b	Ocean Health Index Goal - Clean Waters (0-100)
	14c	Percentage of Fish Stocks overexploited or collapsed by EEZ (%)
	14d	Fish caught by trawling (%)
SDG15	15a	Mean area that is protected in terrestrial sites important to biodiversity (%)
	15b	Mean area that is protected in freshwater sites important to biodiversity (%)
	15c	Red List Index of species survival (0-1)
	15d	Permanent Deforestation, 5 year average annual %
	15e	Imported biodiversity threats (threats per million population)
SDG16	16a	Homicides (per 100,000 population)
	16b	Unsentenced detainees as a proportion of overall prison population
	16c	Proportion of the population who feel safe walking alone at night in the city or area where they live (%)
	16d	Property Rights (1-7)
	16e	Birth registrations with civil authority, children under 5 years of age (%)
	16f	Corruption Perception Index (0-100)

Goal	ID	Indicator
	16g	Children 5–14 years old involved in child labour (%)
	16h	Transfers of major conventional weapons (exports) (constant 1990 US\$ million per 100,000 population)
	16i	Freedom of Press Index
SDG17	17a	Government Health and Education spending (% GDP)
	17b1	For high-income and all OECD DAC countries: International concessional public finance, including official development assistance (% GNI)
	17b2	Other countries : Government Revenue excl. Grants (% GDP)
	17c	Tax Haven Score (best 0-5 worst)

Annex II - Median ranks of countries with 95% confidence intervals

Countries ordered by nominal rank.

	Country	Median rank		Country	Median rank
1	Denmark	1 [1, 1]	41	Ukraine	45 [39, 51]
2	Sweden	2 [2, 2]	42	Romania	41 [37, 45]
3	Finland	3 [3, 7]	43	Uruguay	44 [41, 51]
4	France	4 [4, 8]	44	Serbia	44 [40, 52]
5	Austria	9 [5, 11]	45	Argentina	44 [40, 47]
6	Germany	7 [5, 8]	46	Ecuador	48 [43, 55]
7	Czech Republic	9 [5, 13]	47	Maldives	42 [38, 51]
8	Norway	7 [3, 14]	48	Kyrgyz Republic	52 [46, 61]
9	Netherlands	7 [3, 11]	49	Israel	56 [43, 72]
10	Estonia	12 [6, 17]	50	Greece	54 [44, 66]
11	New Zealand	14 [10, 19]	51	Peru	54 [46, 64]
12	Slovenia	16 [11, 20]	52	Uzbekistan	55 [49, 62]
13	United Kingdom	8.5 [5, 15]	53	Algeria	50 [42, 57]
14	Iceland	16 [11, 24]	54	Vietnam	54 [49, 58]
15	Japan	15 [10, 19]	55	Russian Federation	52 [45, 58]
16	Belgium	15 [12, 20]	56	Cuba	67 [51, 80]
17	Switzerland	15 [9, 25]	57	Brazil	56 [47, 63]
18	Korea, Rep.	21 [14, 25]	58	Iran, Islamic Rep.	55 [47, 64]
19	Ireland	14 [9, 24]	59	Azerbaijan	63 [56, 69]
20	Canada	21 [16, 25]	60	Albania	64 [58, 70]
21	Spain	20 [17, 23]	61	Cyprus	59 [48, 73]
22	Croatia	20 [13, 25]	62	Fiji	64 [57, 71]
23	Belarus	23 [20, 26]	63	Tunisia	60 [51, 67]
24	Latvia	24 [21, 27]	64	Dominican Republic	69 [60, 84]
25	Hungary	26 [22, 29]	65	United Arab Emirates	57 [39, 73]
26	Portugal	27 [25, 28]	66	Singapore	76 [43, 100]
27	Slovak Republic	29 [24, 35]	67	Colombia	68 [61, 75]
28	Malta	26 [20, 32]	68	Malaysia	59 [50, 70]
29	Poland	30 [28, 33]	69	Bosnia and Herzegovina	77 [53, 102]
30	Italy	30 [28, 33]	70	North Macedonia	67 [60, 75]
31	Chile	33 [28, 36]	71	Tajikistan	85 [67, 95]
32	Lithuania	32 [30, 36]	72	Morocco	68 [59, 75]
33	Costa Rica	33 [29, 36]	73	Georgia	76 [71, 82]
34	Luxembourg	27 [14, 39]	74	Jamaica	73 [68, 82]
35	United States	35 [30, 37]	75	Armenia	75 [68, 84]
36	Bulgaria	34 [29, 38]	76	Bahrain	62 [49, 79]
37	Moldova	37 [33, 40]	77	Kazakhstan	74 [64, 81]
38	Australia	39 [35, 58]	78	Mexico	83 [73, 92]
39	China	43 [37, 61]	79	Turkey	77 [72, 84]
40	Thailand	40 [36, 43]	80	Bolivia	74 [68, 81]

	Country	Median rank		Country	Median rank
81	Jordan	82 [75, 88]	122	Guatemala	121 [118, 123]
82	Nicaragua	83 [76, 89]	123	Syrian Arab Republic	123 [121, 126]
83	Oman	75 [65, 86]	124	Senegal	123 [117, 125]
84	Bhutan	81 [72, 87]	125	Kenya	123 [118, 126]
85	Trinidad and Tobago	85 [78, 90]	126	Rwanda	126 [122, 132]
86	Paraguay	82 [76, 87]	127	Cameroon	128 [123, 135]
87	Montenegro	95 [84, 107]	128	Tanzania	127 [125, 131]
88	Suriname	85 [76, 91]	129	Cote d'Ivoire	125 [120, 129]
89	El Salvador	89 [85, 99]	130	Pakistan	131 [125, 140]
90	Panama	86 [76, 98]	131	Gambia, The	128 [126, 131]
91	Qatar	83 [68, 93]	132	Congo, Rep.	134 [130, 141]
92	Egypt, Arab Rep.	91 [85, 96]	133	Yemen, Rep.	146 [132, 153]
93	Sri Lanka	96 [92, 106]	134	Mauritania	132 [128, 138]
94	Lebanon	95 [85, 104]	135	Ethiopia	136 [129, 143]
95	Sao Tome and Principe	97 [90, 104]	136	Mozambique	137 [133, 141]
96	Cabo Verde	96 [92, 101]	137	Comoros	137 [130, 147]
97	Philippines	97 [89, 102]	138	Guinea	140 [134, 145]
98	Saudi Arabia	93 [86, 101]	139	Zambia	141 [135, 148]
99	Gabon	100 [91, 108]	140	Uganda	137 [132, 141]
100	Mongolia	93 [88, 101]	141	Burkina Faso	136 [130, 144]
101	Turkmenistan	106 [94, 113]	142	Eswatini	150 [138, 154]
102	Indonesia	100 [96, 104]	143	Papua New Guinea	145 [140, 149]
103	Nepal	105 [100, 111]	144	Togo	142 [134, 147]
104	Ghana	101 [94, 108]	145	Burundi	152.5 [142, 161]
105	Mauritius	107 [102, 121]	146	Malawi	146 [135, 155]
106	Kuwait	102 [93, 110]	147	Sudan	147 [135, 154]
107	Honduras	106 [100, 110]	148	Djibouti	144 [136, 151]
108	Venezuela, RB	105 [96, 112]	149	Angola	145 [136, 151]
109	Belize	107 [99, 111]	150	Lesotho	150 [129, 155]
110	Myanmar	111 [105, 115]	151	Benin	146 [140, 151]
111	Lao PDR	111 [108, 114]	152	Mali	149 [146, 152]
112	Cambodia	111 [108, 114]	153	Afghanistan	154 [149, 158]
113	South Africa	117 [109, 131]	154	Niger	155 [153, 157]
114	Guyana	113 [110, 116]	155	Sierra Leone	151 [149, 155]
115	India	114 [109, 120]	156	Haiti	153 [146, 157]
116	Bangladesh	117 [114, 123]	157	Liberia	155 [154, 157]
117	Iraq	116 [110, 119]	158	Madagascar	158 [156, 159]
118	Vanuatu	116 [111, 121]	159	Nigeria	159 [152, 160]
119	Namibia	123 [114, 139]	160	Congo, Dem. Rep.	160 [159, 161]
120	Botswana	123 [116, 138]	161	Chad	160 [158, 161]
121	Zimbabwe	119 [116, 122]	162	Central African Republic	162 [162, 162]

GETTING IN TOUCH WITH THE EU

In person

All over the European Union there are hundreds of Europe Direct information centres. You can find the address of the centre nearest you at: https://europa.eu/european-union/contact_en

On the phone or by email

Europe Direct is a service that answers your questions about the European Union. You can contact this service:

- by freephone: 00 800 6 7 8 9 10 11 (certain operators may charge for these calls),
- at the following standard number: +32 22999696, or
- by electronic mail via: https://europa.eu/european-union/contact_en

FINDING INFORMATION ABOUT THE EU

Online

Information about the European Union in all the official languages of the EU is available on the Europa website at: https://europa.eu/european-union/index_en

EU publications

You can download or order free and priced EU publications from EU Bookshop at: <https://publications.europa.eu/en/publications>. Multiple copies of free publications may be obtained by contacting Europe Direct or your local information centre (see https://europa.eu/european-union/contact_en).

The European Commission's science and knowledge service

Joint Research Centre

JRC Mission

As the science and knowledge service of the European Commission, the Joint Research Centre's mission is to support EU policies with independent evidence throughout the whole policy cycle.



EU Science Hub

ec.europa.eu/jrc



@EU_ScienceHub



EU Science Hub - Joint Research Centre



Joint Research Centre



EU Science Hub



Publications Office

doi:10.2760/723763

ISBN: 978-92-76-08995-7