GGGI Technical Report No. 10

ASSESSMENT OF COMPLEMENTARITIES BETWEEN GGGI'S GREEN GROWTH INDEX AND UNEP'S GREEN ECONOMY PROGRESS INDEX

DECEMBER 2019

PART OF GGGI'S TECHNICAL REPORTS SERIES

1. Market Assessment of Fuel Pellets and Green Charcoal for Energy Uses in Senegal, Dereje Senshaw, 2017.
2. Policy Recommendations on Energy for Productive Uses in Rural Areas of Senegal, Dereje Senshaw, 2017.
3. GGPA Synthesis Report, Jan Stelter, 2018.
4. Meeting Global Housing Needs with Low-Carbon Materials, Christina Cheong and Donovan Storey, 2019.
5. Green Growth Index Concept, Methodology and Applications, Lilibeth Acosta, et al., 2019.
6. GGPA Methodology Report, Jan Stelter, 2019.
7. G20 Background Paper: Green Growth to Achieve the Paris Agreement, Frank Rijsberman, Orestes Anastasia, Pranab Baruah, Stelios Grafakos, James Kang, and Dereje Senshaw, 2019.
8. Assessment of Feedback from Regional Expert Consultations on The Green Growth Index (Phase 2), Lilibeth Acosta, et al., 2019
9. Review of GGGI's experience to design and operationalize national financing vehicles to finance climate and green growth policy implementation, Fenella Aouane and Frank Rijsberman, 2019.
10. Assessment of complementarities between GGGI's Green Growth Index and UNEP's Green Economy Progress Index , Lilibeth Acosta, et al., 2019

A collaborative project between the Global Green Growth Institute (GGGI) and United Nations Environment Programme (UNEP)

The Global Green Growth Institute
19F Jeongdong Building, 21-15, Jeongdong-gil
Jung-gu, Seoul, Korea 100-784

United Nations Environment Programme
Palais des Nations, Avenue de la Paix 8-14
1211 Genève 10, Switzerland

Assessment of complementarities between GGGI's Green Growth Index and UNEP's Green Economy Progress Index

Authors

Dr. Lilibeth Acosta
Program Manager, Green Growth Performance Measurement, Global Green Growth Institute

Dr. Jose Pineda
University of British Columbia and United Nations Environment Programme Senior Consultant

Ludovica Galotto
Global Green Growth Institute Consultant

Prapti Maharjan
Global Green Growth Institute Consultant

Fulai Sheng
Senior Economist, Economy Division, United Nations Environment Programme

Please cite this publication as:
Acosta, L., Pineda, J., L. Galotto, P. Maharjan, and F. Sheng. (2019) Assessment of complementarities between GGGI's Green Growth Index and UNEP's Green Economy Progress Index, GGGI Technical Report No. 10, Green Growth Performance Measurement (GGPM) Program, Global Green Growth Institute, Seoul.

Contents

01 INTRODUCTION

Since early 2000s, several international organizations have begun to propose green growth and green economy as a development pathway to achieve economic, social, and environmental sustainability. Green growth and green economy, which have their origin in different organisations and target different groups, are similar in concept and used almost interchangeably (Kasztelan, 2017). For example, frameworks for green growth were promoted by the Organisation for Economic Co-operation and Development (OECD, 2011), the World Bank (WB) (Hallegatte, Heal, Fay, & Treguer, 2012), United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP, 2013), and the Global Green Growth Institute (GGGI, 2017) 2017), while those for green economy were promoted by United Nations Environment Programme (UNEP, 2011), United Nations Conference on Trade and Development (UNCTAD, 2011), United Nations Department of Economic and Social Affairs (UNDESA) (Allen and Clouth 2012), and the Green Economy Coalition (GEC, 2012). Each of these organizations has their own definition and understanding and indicators for frameworks of green growth and green economy.

After a decade, several organizations including the GGGI, OECD, UNEP, UN Industrial Development Organization (UNIDO), and the (WB established the Green Growth Knowledge Platform (GGKP) to promote collaboration in identifying and addressing significant knowledge gaps in green growth theory and practice. In 2013, the GGKP published a scoping paper which was considered the first step towards developing a framework to monitor progress on green growth and green economy (GGKP, 2013). From 2017 to 2019, GGGI engaged many international organizations to develop the conceptual framework for the Green Growth Index, aiming to develop a common global understanding for green growth (Acosta, Maharjan, et al., 2019). Among others, the engagements included conducting international expert consultations in Seoul in February 2017 and in Geneva in June 2018 and international expert group meeting in Rome in December 2018. During this latter event conducted at the Food and Agriculture Organization of the United Nations (FAO) for three days, they deliberated and agreed on how to integrate the feedback from the regional experts[1] into the Green Growth Index's framework.

There are few green growth and green economy indices that exist[2]: the African Development Bank's (AfDB) African Green Growth Index (AfDB 2014), the Dual Citizen LLC (DC) Global Green Economy Index (Tamanini, Bassi, Hoffman and Valenciano 2014), UNEP's Green Economy Progress Index (PAGE, 2017a, 2017b), the Asian Development Bank (ADB) Inclusive Green Growth Index (Jha, Sandhu, & Wachirapunyanont, 2018), and the GGGI's Green Growth Index (Acosta, Maharjan, et al., 2019). But do we need different indices? This is a valid question that needs to be addressed. DC's framework for the Global Green Economy Index "departs from the classic green growth narratives, in particular, by excluding social inclusion indicators" (Acosta, Maharjan, et al., 2019). On the other hand, the AfDB, UNEP, ADB, and GGGI's indices highlight the importance of inclusive green growth and green economy. AfDB and ADB's green growth indices are focused on the regional contexts and require a framework that captures specificities of the region's economic, social, and environmental system. GGGI and AfDB are currently collaborating to adapt GGGI's green growth framework for AfDB's Green Growth Index. Both GGGI's Green Growth Index and UNEP's Green Economy Progress Index (referred to as GG Index and GEP Index, respectively, in this report) have global coverage and emphasize social inclusion in their frameworks. It will thus not be surprising if users of these indices ask:

? *"How are these indices different from or similar with each other?"*

Not only GGGI, but also the UNEP engaged other international organizations in developing the GG and GEP Indices. The GEP Index was developed through the PAGE, composed by UNEP, UNIDO, International Labour Organization, UN Development Programme, and UN Institute for Training and Research. During GGGI's two-day international expert workshop in June 2018, which was jointly organized by GGGI and GGKP in Geneva, GGGI and UNEP agreed to collaborate more closely to ensure that GG and GEP Indices will be developed as complementary tools. With the support of the GGKP Working Group on Measurement and Indicators, the two organizations planned to work on country case studies to apply both indices in 2019. The collaboration aimed to publish this report showing to the users and stakeholders, including the policymakers who participated in GGGI's regional workshops on the Green Growth Index in 2018 (Acosta, Mamiit, et al., 2019), the differences and complementarities between the two Indices.

This report is organized as follows: **section 2** briefly introduces the analytical approach for the comparative assessment; **section 3** focuses on the descriptive assessment and discusses the main similarities and differences between the GG and GEP concept and methods; **section 4** focuses on empirical assessment and presents the results from the global applications of both indices as well as a detailed discussion of the results for two country case studies, Mexico and China, and the results for a common application of both methodologies for a selected number of common indicators and key parameters; and **section 5** concludes the report.

[1]Two-day regional workshops on the Green Growth Index were conducted by GGGI in Bangkok, Thailand for Asia-Pacific Region; in Dubai, United Arab Emirates for Middle East and North Africa (MENA) Region; in Addis Ababa, Ethiopia for Africa Region; and Mexico City, Mexico for Latin America and the Caribbean (LAC) Region from August to October 2018. The workshops, participated mainly by policymakers, aimed to gather feedback on the policy relevance of the indicators included in the Green Growth Index.
[2]The list excludes green growth measures which are not combined into a composite index (dashboards, footprints and adjusted measures). Acosta et al. (2019) provides a comparative assessment of these four green growth and green economy indices to GGGI's Green Growth Index.

02 ANALYTICAL APPROACH

For the preparation of this report, a three-day workshop meeting was held in Geneva on 13-15 August 2019, with participants from GGGI and UNEP, as well as the international experts in charge of preparing the report. The main outputs from this workshop were a preliminary outline of the report, the case study countries for the assessment, and the set of indicators and key parameters for the common application. Based on these, two types of analyses were conducted for a systematic comparative assessment of the GGGI's GG Index and UNEP's GEP Index – descriptive and empirical (Figure 1). The results from the two analyses were assessed to determine the degree of complementarities between GG and GEP Indices.

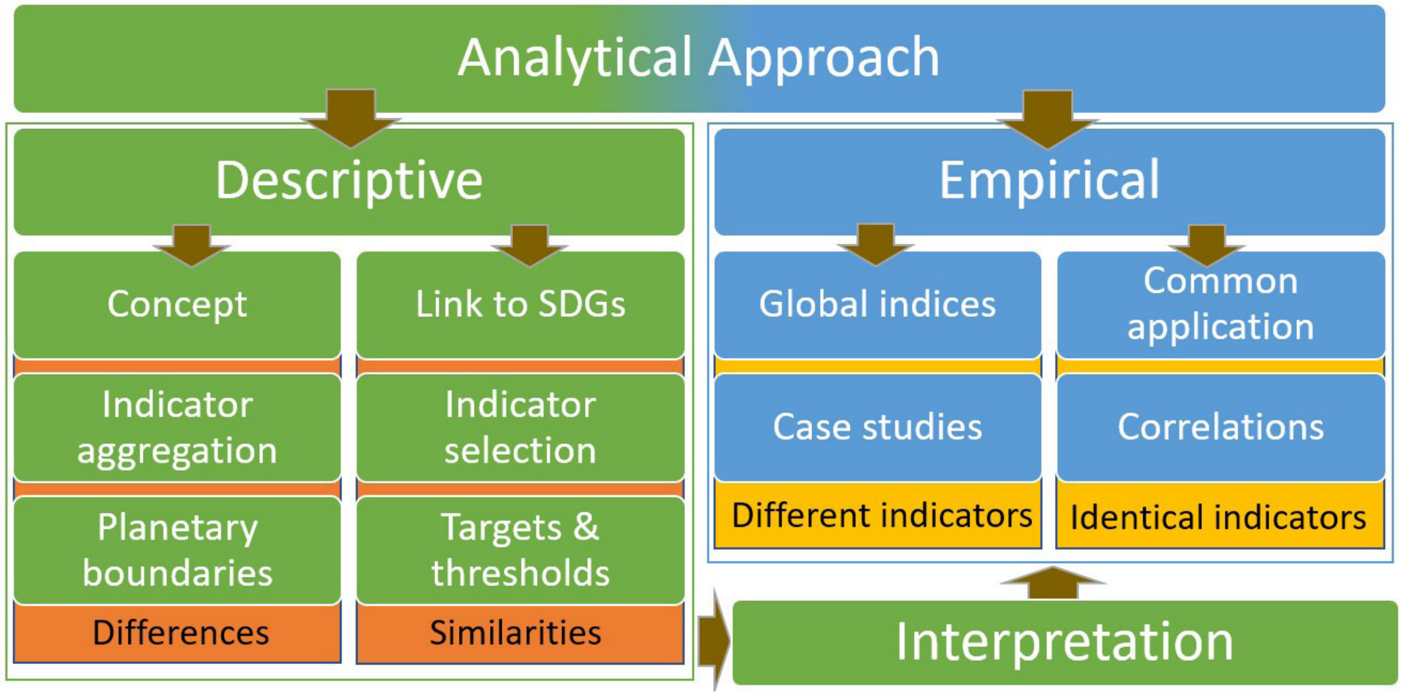


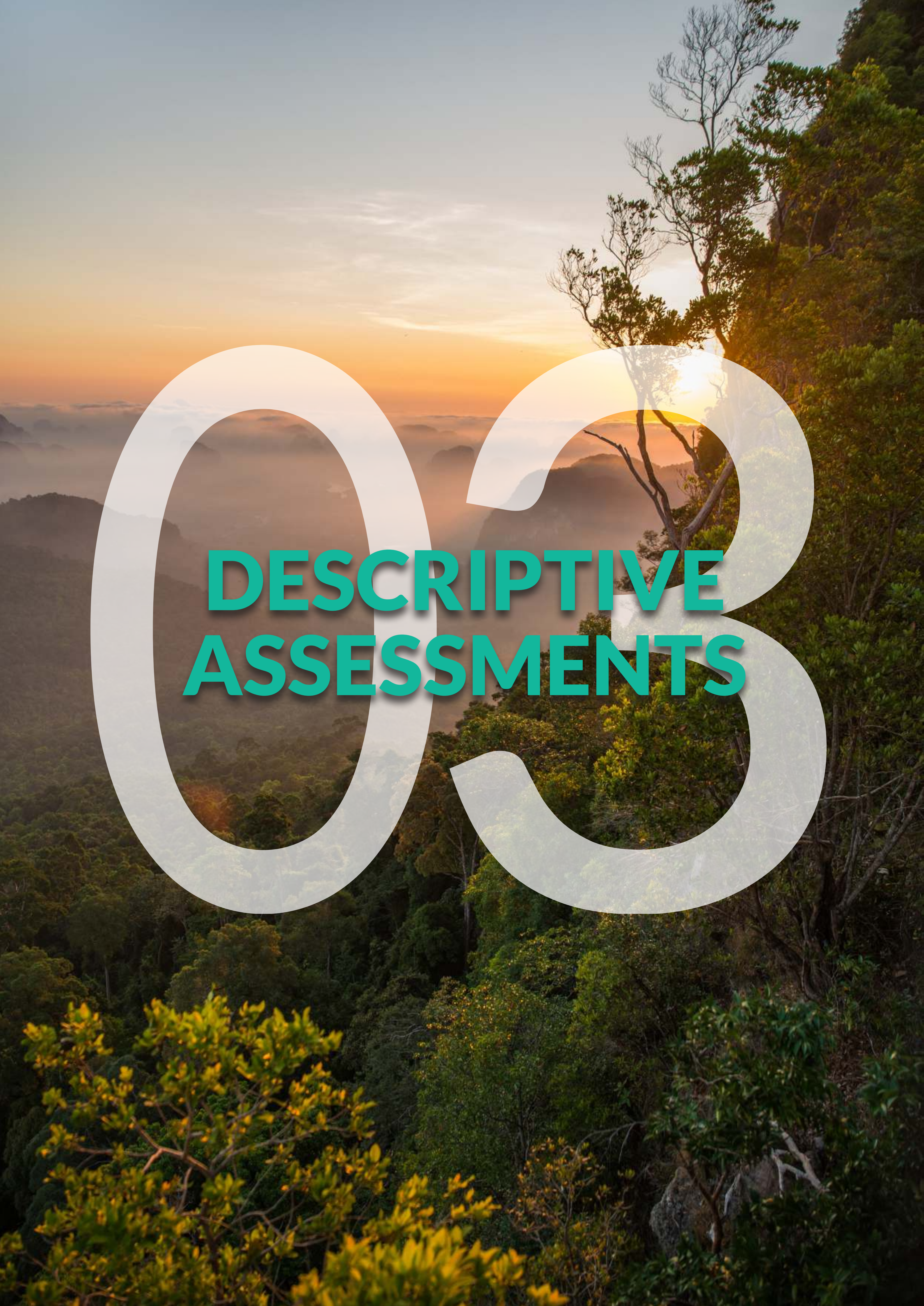
Figure 1. Analytical Approach to assess complementarities between the indices

The descriptive analysis compares the two indices based on the theoretical framework and the methodology used for the index's construction, highlighting the differences and similarities. First, the differences between the indices are highlighted. These are the different conceptual foci; the methodologies of aggregation and steps prior to aggregation such as checking for outliers and assigning weights; and the approach for including the planetary boundaries' narrative in the frameworks. The second part of the descriptive analysis focuses on the commonalities between the indices, which are the links to SDGs, the process for selecting indicators, and the way of interpreting targets and thresholds.

After comparing the differences and similarities, the interpretation is presented for the key elements of the GG and GEP Indices such as scores for performance and progress, weights, targets, and ranks. This serves to bridge the two types of analyses, providing a summary of the descriptive analysis, and guide to understanding the results from the empirical analysis.

The empirical analysis is divided into two applications – first, global application using the different set of indicators from the GG Index (36 indicators) and GEP Index (13 indicators), and second, the common application using eight indicators that are the same for both Indices. The first analysis that dealt with the global application of the two Indices used their respective original sets of indicators. It analyzed not only global and regional results but also detailed results for two case studies – China and Mexico. These countries were selected because they are either member or partner countries of GGGI and UNEP/PAGE. The second analysis applied the Indices' respective methods on common sets of indicators and checked correlations of the results from the application of these common indicators. The analysis included scatter plot of country ranks and scores as well as correlation of indicators to assess the degree of relationship between the GG and GEP Indices.

03 DESCRIPTIVE ASSESSMENTS



3.1 Differences

3.1.1 Conceptual framework

The GG and GEP Indices have several similarities because their conceptual narratives and frameworks were guided by the GGKP's scoping paper (GGKP, 2013). In this scoping paper, the GGKP evaluated green growth indicators and proposed a framework that provides a common basis for further developing green growth and green economy indicators, with a special focus on the economy-environment nexus. The framework was the result of the joint efforts by experts from the GGGI, OECD, UNEP, and WB. Thus, the two indices were built on a common understanding of the conceptual framework for selecting indicators[3] and the principles for constructing a robust index for green growth and green economy. However, the GG and GEP Indices strongly differ in their focal points. The GG Index concentrates on the countries' performances on four green growth dimensions while the GEP Index focuses on the progress made by countries towards an inclusive green economy (Table 1). In the construction of each index, the different foci have a strong impact on the methodological choices: the indicators included in the GG Index measure the levels of performances at a precise point in time, while those in the GEP Index assess changes over time.

Table 1. Differences in the concepts of the Green Growth and Green Economy Progress Indices

Aspect	Green Growth Index	Green Economy Progress Index
Definition	Green growth is a development approach that seeks to deliver economic growth that is both environmentally sustainable and socially inclusive. (GGGI, 2017: p.12)	An Inclusive Green Economy is a pathway designed to address three main global challenges, namely: (a) persistent poverty; (b) overstepped planetary boundaries; and (c) inequitable sharing of growing prosperity. (PAGE, 2017b: p.3)
Thematic focus	Country performance on four green growth dimensions for efficient and sustainable resource use, natural capital protection, green economic opportunities, and social inclusion.	Country progress on 13 green economy indicators for resource efficiency/ economic, social, and environmental aspects; and 6 planetary boundary indicators.
Temporal focus	Current performance	Progress over time

GGGI's definition emphasizes four closely interlinked concepts that support green growth and sustainable development: low carbon economy, ecosystem health, resilient society, and inclusive growth. Related to these concepts are the four dimensions that constitute the GG Index – **efficient and sustainable resource use**, natural capital protection, green economic opportunities, and social inclusion (Figure 2). According to the GG Index's narrative, efficient and sustainable resource use entails more productive use of natural resources and more cumulative economic value with less resources without endangering the needs of future generations (ECN, 2013), focusing not only on physical resources such water, energy, land, and materials, but also on ecosystem services. Without **natural capital protection**, these conditions that support ecosystem services are at risk. Green Growth emphasizes the role of natural capistal in generating new sources of growth and expanding **economic opportunities** in the form of green investment, employment, etc. (OECD 2011). This new model of growth focuses on people (Bass et al., 2016), where **social inclusion** becomes a key mechanism to ensuring people's contribution to, sustaining opportunities, and distributing benefits from economic growth.

[3] These are policy relevance, analytical soundness, measurability and usefulness in communication (GGKP 2013)

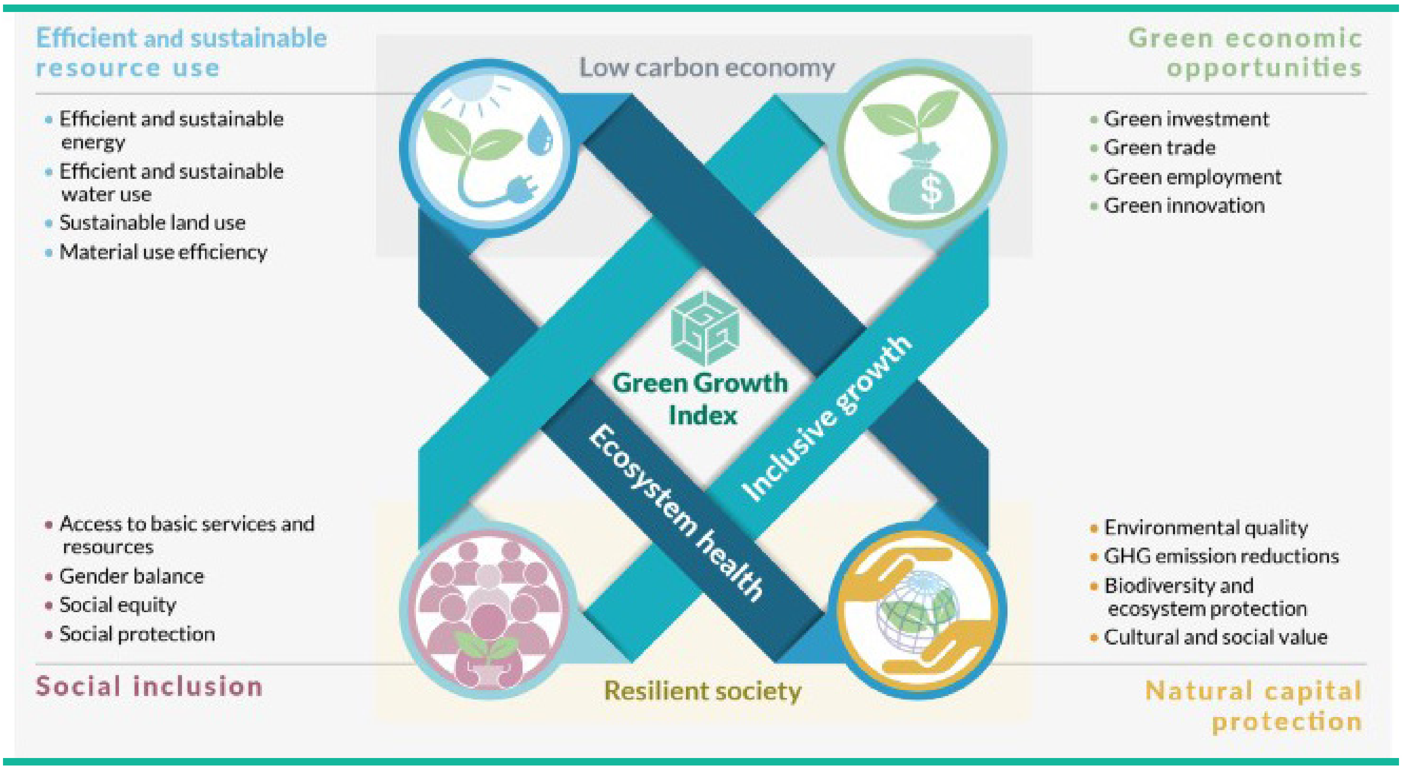


Figure 2. Conceptual framework for the Green Growth Index
Source: Green Growth Index - Concepts, Methods and Applications (Acosta, Maharjan, et al., 2019)

Based on the above narrative, the GG Index's framework is structured in four levels: the Index as an overarching measure of green growth performance, the four dimensions as intermediate goals to achieving green growth, the four indicator categories serving as sustainability pillars in each dimension, and the different indicators providing policy relevant metrics for measuring green growth performance and distance to sustainability targets (Acosta, Maharjan, et al., 2019). The indicators, expressed in levels, measure the phenomena described in the narrative: the indicators for efficient and sustainable resource use represent the use of major natural resources including energy, water, land, and material; and the indicators for green economic opportunities include investment, trade, employment, and innovation (these two dimensions and their indicators are relevant to the concept of low carbon economy). The indicators for natural capital protection include environmental quality, GHG emissions reduction, and biodiversity and ecosystem conservation. The indicators for social inclusion include access to basic services and resources, social equality, and social protection (these two dimensions and their indicators are relevant to the concept of resilient society).

UNEP's definition of the Inclusive Green Economy highlights the overarching goal of poverty eradication and shared prosperity in an intergenerational context by safeguarding planetary boundaries (Table 1), some of which include climate, freshwater, ocean, and land. Planetary boundaries should serve as drivers for innovative solutions that respect ecological thresholds while improving the livelihoods of communities around the world. Moreover, the Inclusive Green Economy promotes the creation or enablement of a new generation of capital that includes natural capital, low carbon, resource efficient physical capital, human capital with modern and green skills, and social capital that ensures equity and inclusiveness. This new generation of capital will serve as input in the production of environmentally friendly goods and services to be absorbed by the economy. The GEP Measurement Framework is, however, not limited to the production sphere; it also encompasses indicators that are linked to addressing poverty eradication and overstepped planetary boundaries.

Based on the Inclusive Green Economy analytical narrative, the GEP Measurement Framework is composed of a GEP Index and a companion Dashboard of Sustainability indicators (Figure 3). The GEP Index is used to track the changes in green economy indicators relative to desired changes, which directly or indirectly impact current human well-being. It captures particular characteristics of the Inclusive Green Economy concept with a set of multidimensional indicators that cover aspects of at least two dimensions of sustainability (e.g. indicators that capture the link between health and the environment). Moreover, it reflects the weighted progress achieved by countries with respect to targets set within planetary boundaries and relevant critical thresholds across several indicators. The value of the GEP Index enables countries to gain an overview of their progress towards greening the economy. Thus, the indicators that compose the GEP Index are expressed in terms of progress made (i.e. the changes rather than the levels) by countries on the key indicators to achieve an Inclusive Green Economy. The GEP Index and Dashboard are combined to allow the ranking of progress (GEP+) by country (see sections 3.1.3 and 3.3.2 for more details on the Dashboard and GEP+, respectively).

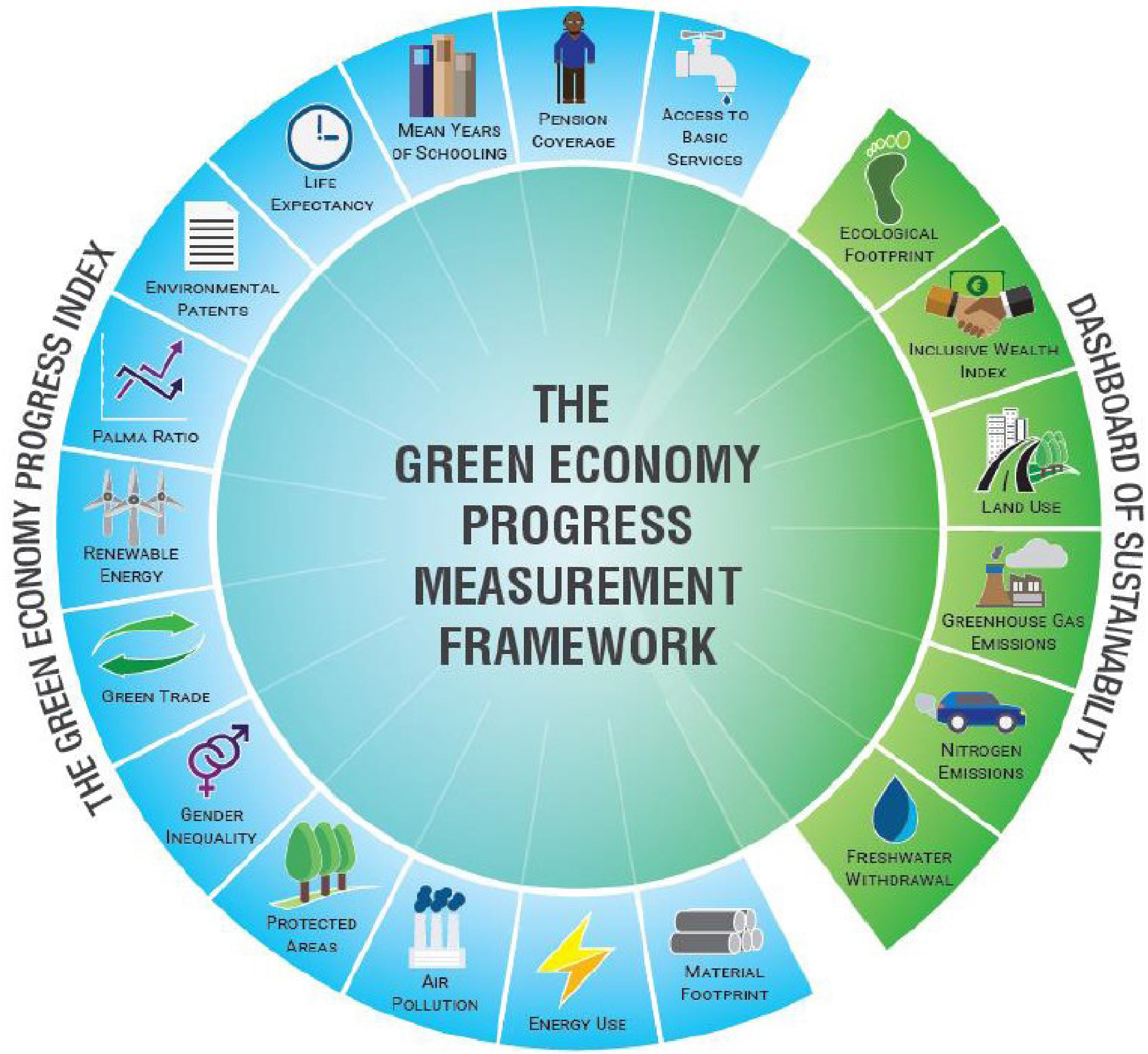


Figure 3. Conceptual framework for the Green Economy Progress Index and Dashboard
Source: The Green Economy Progress Measurement Framework – Application (PAGE, 2017a).

3.1.2 Indicator aggregation

This section discusses differences in steps during aggregation of indicators (i.e. weights) and preparation of indicators prior to aggregation (i.e. outliers).

Outliers: Checking for outliers (or extreme values) is one of the most important steps prior to aggregation of indicators.

The GG and GEP Indices employ different ways of dealing with outliers (Table 2). The main differences in this aspect is the number of indicators considered in the capping process (all indicators in the GG Index case and only some in the GEP Index case), and the methodologies used for capping values in the presence of such outliers (another value of the distribution in the GG Index and a missing value for the GEP Index).

Table 2. Differences in steps prior to and during aggregation of indicators in Green Growth and Green Economy Progress Indices

Aspect	Green Growth Index	Green Economy Progress Index
Outliers	Extreme values were identified using interquartile range across all indicators. Capped outliers were replaced by the values of either the sustainability targets, or the lower or upper fences (i.e. depending on whether outliers are beyond lower or above upper fences).	Extreme values were identified based on indicator-specific rules. Values were capped only when indicators were highly likely to have measurement errors and capped values were treated as missing values.
Weights	Indicators are assumed to have implicit equal weights (i.e. no weights were assigned).	First weight ($\hat{\pi}$) of each indicator is ratio between the critical threshold and the initial value of the indicator (equation 3). Re-weighing of the first weight ($\hat{\pi}$) to get a second weight (π) (equation 4).
Normalization	Re-scaling or Min-max method that integrates sustainability targets as upper bounds (equation 2).	Normalized through re-weighing.
Aggregation	Arithmetic mean for aggregation of normalized indicators (level 1) and geometric mean for aggregation of indicator categories (level 2) and dimensions (level). (Figure 4)	Weighted average by taking the arithmetic mean of the normalized weights (π) of the indicators.

The GG Index's methodology defines extreme outliers (observed values that have an "abnormal distance" from other values of a dataset) using a rule that depends on the distribution of the data. The outliers are defined as the values exceeding the upper and lower fence, computed as follows:

EQUATION 1:

IQR = 75th percentile – 25th percentile
Lower fence = 25th percentile – μ×IQR
Upper fence = 75th percentile + μ×IQR

Where IQR = interquartile range, μ = 3.0 (the multiplier).

Values which are identified as extreme outliers (i.e. values above the upper fence or below the lower fence) are then excluded from the sample and replaced by other values (i.e. are capped). Many of the outliers did not need to be capped because outliers naturally disappear in the re-scaling and benchmarking process. Re-scaling method, also known as min-max transformation, was chosen to normalize the indicators in the GG Index. Benchmarking is included into the re-scaling method (i.e. **normalization**), so that variables are scaled taking into account a sustainability target (equation 2). Every time the maximum (minimum) values of the distribution of a variable exceed the maximum (minimum) sustainability target, the re-scaling automatically corrects the presence of the outliers by giving them the maximum value (100). It is important to note that through normalization, all indicators were transformed to have positive relationship to green growth (e.g. 100 score for municipal solid waste generation implies that a country has the lowest level of waste generation per capita).

EQUATION 2:

$$X_i^{norm} = a + \left(\frac{x_i - X_{min}}{X_{max} - X_{min}}\right)(b - a)$$

where: a = lower bound
b = upper bound
where lower bound = 1 and
upper bound = sustainability target

When extreme outliers were not capped through benchmarking (i.e. the outliers rest on the part of the distribution where the benchmark is not applied or there was no value exceeding the target), they are capped prior to normalization (Equation 2). Capping outliers imply replacing extreme values with other values which more or less correspond to the structure of the rest of the dataset (i.e. normal distribution). The GG Index used the value of the lower and upper fences depending on whether the extreme outliers are beyond lower or upper fences.

The GEP Index's methodology, rather than identifying outliers based on the indicators' distribution, used indicator-specific rules based on this criteria: values were capped only when they were highly likely to be measurement errors and their inclusion would have a great impact on the overall index. So, while the capping in the GG Index mainly involved quantitative assessment of the indicators, the GEP Index also involved expert judgement on the likelihood of measurement errors. For the GEP Index, there was no capping for most indicators, allowing to integrate all the observed changes in the different indicators. However, some indicators showed that all possible progress has been fully achieved and no additional progress can be expected. Examples of and remedies for these cases were as follows:

- A country's initial value for access to basic services was very high (e.g. over 97%) and impossible to achieve further progress. In this case, the indicator value was treated as a missing value and excluded from the calculation of the Index.
- A country's initial value for access to basic services was very low level and progress may be magnified due to problems in data measurement (e.g. 0.1% initial value and 0.2% progress). In this extreme case, the initial value was replaced by a missing value for the corresponding indicator and progress was measured based on achievements in the remaining indicators.

It is important to note that this indicator-specific approach strongly relied on thorough data check and good knowledge of the indicator.

Weights: Given the different foci of the GG and GEP Indices' frameworks, the weighting methods used in the construction of the indices are different. The GG Index used equal weighting across indicators and countries, reflecting the idea that all components are equally important for determining the performance of a country. However, the specific number of indicators within each dimension alters its relative weight across dimensions (i.e. more weight is implicitly given to the indicators in the dimensions with lower number of indicators). The aim for applying a straightforward method for developing weights was to allow replicability of the GG Index's methods in GGGI's member countries by its country offices and/or government partners. But as more relevant green growth indicators become available in the future, GG Index will aim to have equal number of indicators to explicitly define equal weights across dimensions (Acosta, Maharjan, et al., 2019).

For the GEP Index, different weights across indicators and countries were used, adopting a method based on country-specific data to build the weights. By employing information on initial countries' characteristics relative to critical thresholds, the GEP Index's weights embody the assumption that progress is more relevant for those indicators on which initial conditions are worse. The construction of the GEP Index utilizes two weighting approaches: first, weight that assesses how far off a country is from the global threshold; and second, weight that evaluates the relative importance of one indicator with respect to the other indicators. Combining both approaches enhance the policy relevance of the GEP Index at the local (i.e. progress of a country with respect to specific indicators) and global (i.e. comparing progress across countries) levels and its usefulness for setting policy priorities. GEP Index's methodology on calculating the two types of weight is elaborated below.

The indicators are defined as either "goods" or "bads", where goods contribute positively to progress and bads contribute negatively to progress. In other words, goods have positive and bads have negative relationship to achieving goals for green economy. The methods for calculating the first set of weights ($\hat{\pi}$) for indicators that are goods and bads are different. For goods (G), they are calculated as the ratio between the critical threshold over the initial value of the indicator (e.g. share of renewable energy). For bads (B), they are calculated as the ratio between the initial value over critical threshold of the indicator (e.g. air pollution). The formula for calculating the weights is:

EQUATION 3:

$$\hat{\pi}_j = \begin{cases} \dfrac{t_j}{y_j^0}, & if\ j \in G \\[2ex] \dfrac{y_j^0}{t_j}, & if\ j \in B \end{cases}$$

Where tj is the critical threshold related to the indicator j and y_0j is the initial value of indicator j. For the goods (G), the weight is lower if the indicator's initial value is higher with respect to the critical threshold (which is the minimum critical value for the indicator to remain sustainable). For the bads (B), the weight is lower if the initial value of the indicator is smaller as compared to the critical threshold (maximum value that the variable should not exceed in order to remain sustainable). Thus, this formulation gives more weight to progress on those indicators in which countries are starting at an initially disadvantaged position (i.e. low initial value) in relation to the critical threshold, but are exerting efforts to make progress or remain at sustainability level.

The second set of weights (π) takes into consideration the relevance of progress in one indicator vis-à-vis the other indicators. The second weights were obtained by the re-weighting (i.e. **normalization**) of the first set of weights as follows:

EQUATION 4:

$$\pi_j = \frac{\hat{\pi}_j}{\sum_{j \in J} \hat{\pi}_j}$$

The second set of weights indicates the relative importance of one indicator compared to the others.

Aggregation: The aggregation methods used by the GG and GEP Indices are also different. The GG Index used a mix between arithmetic and geometric means for its three levels of aggregation, while the GEP index used a weighted average aggregation of the progress achieved on each indicator. Geometric mean was applied to the four green growth dimensions (i.e. level 3 of aggregation) to compute for the GG Index and arithmetic mean was applied on the normalized weights (i.e. second weights computed from equation 4) to construct the GEP Index. However, since there is a connection between aggregating with geometric mean in levels and aggregating with a weighted arithmetic mean in changes, the aggregation methods can be considered comparable. For the GEP Index, calculation of the index was conducted only when there was a limited number of missing observations for a given country (i.e. a country should have at least 10 out of 13 indicators to be on the sample).[4] GG Index's methodology for aggregation is elaborated below.

The GG Index resulted from aggregation at three different levels: the 36 normalized indicators (i.e. computed from equation 2) were aggregated into the 16 indicator categories, which are in turn combined into the four dimensions that formed the overarching Index (Figure 4). The aggregation method at three different levels ensures that as the level of aggregation increases, the level of substitutability decreases. At level 1, the normalized indicators were linearly aggregated into indicator categories using the **arithmetic mean.** An important consideration here is the compensability of the individual indicators in each indicator category. This allows countries with poor performance in one indicator to be compensated by another indicator in the same indicator category. In most cases, the level of correlation between indicators in the same category is not negligible (i.e. it is assumed that they have some degree of substitution). Moreover, at level 1 of aggregation, a rule on missing value for a category with more than four indicators was applied: countries with over 25% missing values were dropped. At level 2, **geometric aggregation** was applied to the indicator categories to allow only partial compensability between indicators in each dimension. At the dimension level, **geometric aggregation** was applied, and no dimension was allowed to easily substitute the other dimensions to improve the GG Index. In practice, the latter implies that the Index is not computed if scores for at least one dimension is missing due to lack of data.

3.1.3 Planetary boundaries

Both the GG and GEP Indices are linked to the framework on Planetary Boundaries proposed by Rockstrom et al. (2009) and the selection of some of the indicators and critical threshold (boundary values) were guided by this framework. However, these Indices differ not only with respect to the number of planetary boundary indicators (Table 3), but also the way in which these indicators are treated within the Indices' frameworks. The GG Index included the planetary boundary indicators as part of the natural capital dimension and thus integrated in the construction of the Index (Figure 2). On the other hand, the GEP Index separated these indicators from the Index and presented them as part of a dashboard (Figure 3). As such, the GEP Index does not allow a compensation among its six planetary boundary indicators and other indicators. Following three levels of aggregation, the GG Index allows full compensation of three indicators at the first level of aggregation, i.e. indicator level. However, it only allows partial compensation between four indicator categories in the second level of aggregation and no compensation with other green growth dimensions in the final level of aggregation (see section 3.1.2 and Figure 4).

[4] To determine the sample of countries of the GEP Index, the availability of indicators was reviewed. Only 11 countries have all 13 indicators; 48 countries have 12 or more indicators; 88 countries have 11 or more indicators, while 105 countries (the selected sample) have 10 or more indicators. For countries with missing values, weighting in the GEP Index is adjusted accordingly.

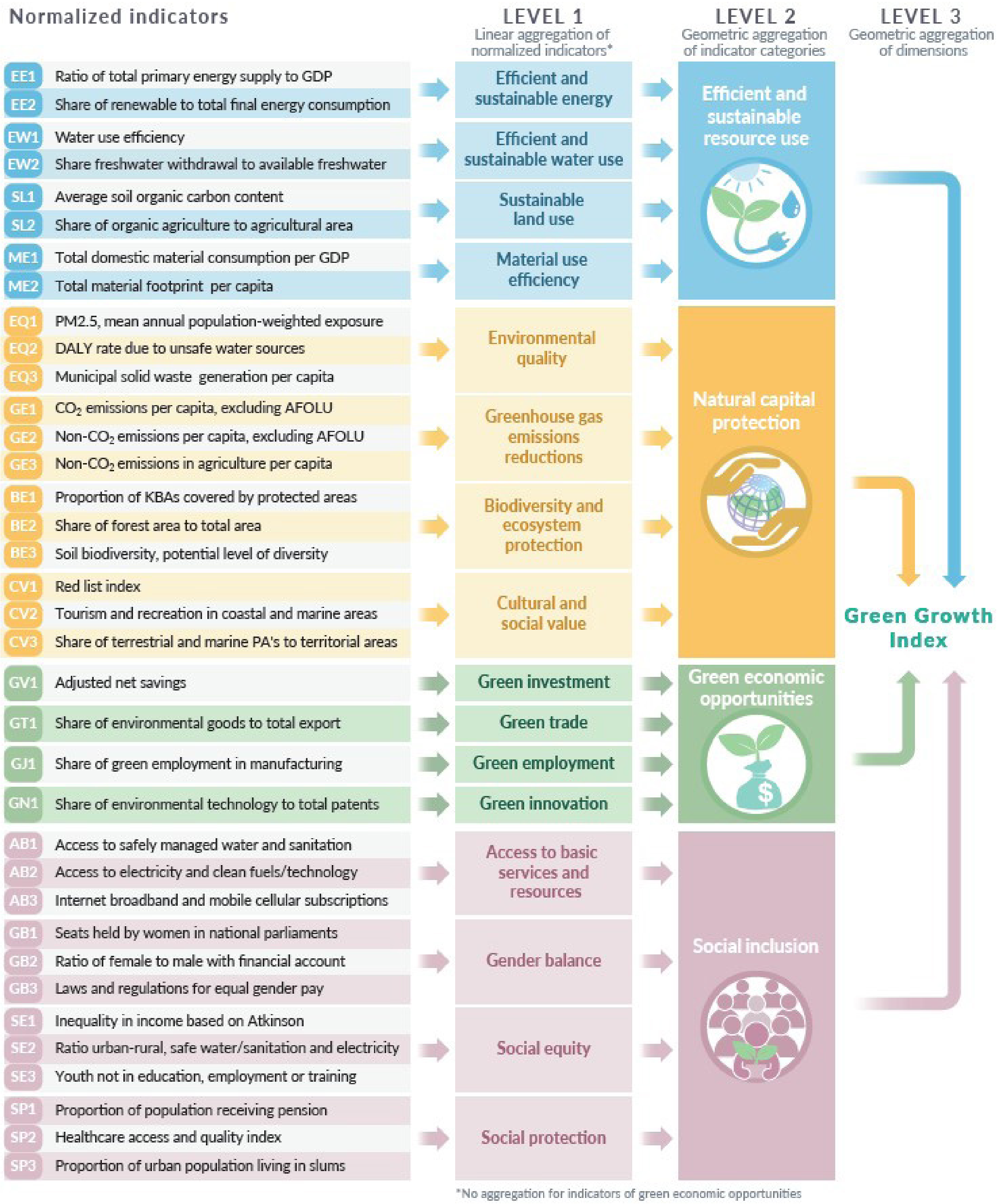


Figure 4. Three levels of aggregation in the Green Growth Index

Table 3. Differences in indicators for the nine planetary boundaries in Green Growth and Green Economy Progress Indices

Aspect	Green Growth Index	Dashboard of Environmental Sustainability used in the Green Economy Progress Measurement Framework
1. Climate change	GE1: Ratio of CO2 emissions to population, excluding AFOLU (Metric tons per capita) GE2: Ratio of non-CO2 emissions to population, excluding AFOLU (Tons per capita) GE3: Ratio of non-CO2 emissions in agriculture to population (Gigagrams per 1000 persons)	Greenhouse gas emissions (CO2e/capita/year)
2. Biodiversity loss	BE1: Average proportion of Key Biodiversity Areas covered by protected areas (Percent) BE3: Soil biodiversity, potential level of diversity living in soils (Index) CV1: Red list index (Index)	Ecological footprint (global hectares/capita) Inclusive Wealth Index – Natural Capital (millions of constant 2005 US$/capita)
3. Land-system change	BE2: Share of forest area to total land area (Percent) CV3: Share of terrestrial protected areas to total territorial areas (Percent)	Land use (share of land used for permanent crops)
4. Freshwater use	-	Freshwater withdrawal (m3/capita/year)
5. Particle pollution	EQ1: PM2.5 air pollution, mean annual population-weighted exposure (Micrograms per m3)	-
6. Chemical pollution	EQ3: Municipal solid waste (MSW) generation per capita (Tons per year per capita)	-
7. Biochemical flows	EQ2: DALY rate as affected by unsafe water sources (DALY lost per 100,000 persons)	Emissions of nitrogen (kg/capita/year)
8. Ocean acidification	CV2: Tourism and recreation in coastal and marine areas (Score) CV3: Share of marine protected areas to total territorial areas (Percent)	-
9. Ozone depletion	-	-

The GG Index framed planetary boundaries as natural capital that requires protection. Natural capital protection is necessary so that natural assets continue to provide environmental services on which our well-being relies (OECD 2011). Natural capital exists independently but the benefits can only be derived from the intervention of human beings (Natural Capital Committee 2014). Historically, most countries around the world have exploited natural capital for the sole purpose of economic growth with limited considerations of environmental impacts. This resulted to significant adverse impacts on biodiversity and aggregated resource depletion. This directly jeopardizes the very objective of green growth, which is to recouple environmental protection with the economy (Vazquez-Brust 2014). Because natural capital is very much interlinked with the economy and society, its protection is included in the GG Index to represent these interlinkages. On the one hand, efficient and sustainable resource use and green economic opportunities should be able to contribute to natural capital protection and, on the other hand, social inclusion and green economic opportunities should benefit from natural capital protection (Acosta, Maharjan, et al., 2019). The GG Index's natural capital protection dimension covers seven of the nine Planetary Boundary indicators, while GEP Index's dashboard covers five (Table 3). Almost all indicators for natural capital protection dimension contribute directly to achieving the objectives of planetary boundaries, except for DALY rate as affected by unsafe water sources. The indicator on unsafe water sources was used to capture biochemical flows including nitrate-nitrogen pollution from agricultural practices and sewerage (WHO, 2014). The GG Index also considers the radiative forcing effects of non-CO2 emissions, particularly nitrous oxide, on climate change (Rockström et al., 2009).

The indicators in the GEP Index are outcome (or performance) indicators that are affected by policy choices, and the Index aims to monitor their evolution over time. By contrast, the indicators in the GEP Dashboard are state indicators that monitor stocks to assess progress within planetary boundaries. The criteria used for selecting the indicators for the dashboard are the same as for the GEP Index, but a fourth criterion applies uniquely to the dashboard indicators: they should reflect a global planetary boundary for which there is evidence suggesting that the thresholds are determined on the basis of the best available scientific knowledge. After reviewing the literature with the objective of including the largest country coverage possible, only six indicators were included in the dashboard, namely: (a) greenhouse gas emissions per capita; (b) nitrogen emissions per capita; (c) share of land use for permanent crops; (d) freshwater withdrawal per capita; (e) the Inclusive Wealth Index; and (f) the Ecological Footprint. The GEP Dashboard of Sustainability monitors key stocks of capital that are priorities to sustain life on the planet. Any loss in these key capital stocks cannot be compensated by increasing another stock of capital. Progress in these areas can therefore only be assessed for each indicator individually, not as an aggregate index. The role of the dashboard is to keep track of the long-term sustainability of the factors that support human well-being by complementing the information assessment of green economy progress in the GEP Index.

3.2 Similarities

3.2.1 Indicators' link to SDGs

The GG and GEP Indices' frameworks are both closely related to the Sustainable Development Goals (SDGs) narratives. In fact, they both share the aim of supporting the assessment of progress in achieving selected SDG targets within the 2030 Sustainable Development Agenda. This is reflected in the selection of indicators, which primarily rely on the indicators proposed in the SDG framework. In addition to using SDG indicators, the GG Index also integrates the SDG targets in the benchmarking process. An unintended difference results from the time in which the index was constructed: more SDG indicators and targets were available at the time when the GG Index was published (Acosta, Maharjan, et al., 2019) as compared to the time when the GEP index was published (PAGE, 2017a, 2017b). The GG Index addresses 16 and GEP Index addresses 13 out of the 17 SDG indicators (**Table 4**). The GEP Index's intention of using indicators from SDGs or related to the SDGs was to construct a useful tool that could bridge national and international assessment of progress and assist countries as they seek to monitor and deliver on the SDGs. This will help not only in the monitoring process but also in the integration and articulation of policies by enhancing the linkages between green growth policies to the overall objectives of sustainable development.

The GG Index is intended to be used to measure and track the green growth performance of countries worldwide, thus it integrates many SDG indicators in its framework. The reason for including the SDGs within the framework is twofold. First, the SDG indicators are reliable and comprehensive dataset which provide an excellent source for the construction of the Index. Furthermore, for all UN member governments having agreed to reach specific targets in SDGs, it is necessary for the GG Index to be aligned with the SDGs in order to make it relevant to national policy worldwide. For all these reasons, the GG Index uses the SDG indicators in its assessment of green growth performance. Where possible, the United Nations Statistics Division (UNSTAT)-SDG indicators were used directly in the GG Index (**Table 4**). For other indicators, data were not available in the UNSTAT-SDG, but they are nonetheless very related to SDG indicators. These indicators are either important to achieving targets in other international agreements (e.g. Paris Climate Agreement, Aichi Biodiversity Target), or relevant to sustainable development.

Table 4. Links of GG and GEP indicators to Sustainable Development Goals (SDGs)

Goal	Green Growth Index		Green Economy Progress Index and Dashboard	
	SDG indicators	Related to SDG indicators	SDG indicators	Related to SDG indicators
Goal 1: End poverty in all its forms everywhere	(1.3.1) Proportion of population receiving pension (1.4.1) Percentage of the population with access to basic services (water, sanitation, electricity, clean fuels)	(1.1.1) Inequality in income based on Atkinson	(1.3.1) Proportion of population receiving pension (1.4.1) Percentage of the population with access to basic services (water, sanitation, and electricity)	(1.1.1) Palma ratio
Goal 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture	(2.4.1) Share of organic agriculture to agricultural area			
Goal 3: Ensure healthy lives and promote well-being for all at all ages	(3.9.1) PM2.5 pollution mean annual exposure (3.9.2) DALY rate due to unsafe water sources	(3.8.1) Healthcare access and quality index	(3.1.1) Maternal mortality ratio in Gender Inequality Index (3.7.2) Adolescent birth rate in Gender Inequality Index (3.8) Life expectancy at birth (3.9.1) PM2.5 pollution mean annual exposure	
Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for al		(4.3.1) Share of youth not in education, employment or training, aged 15-24 years		(4.1.1) Mean years of schooling in Gender Inequality Index
Goal 5. Achieve gender equality and empower all women and girls	(5.5.1) Seats held by women in national parliaments	(5.1) Ratio of female to male with financial account (5.c) Laws and regulations for equal gender pay	(5.5.1) Seats held by women in national parliaments in Gender Inequality Index	(5.6.1) Adolescent birth rate in Gender Inequality Index

Goal	Green Growth Index		Green Economy Progress Index and Dashboard	
	SDG indicators	Related to SDG indicators	SDG indicators	Related to SDG indicators
Goal 6: Ensure availability and sustainable management of water and sanitation for all	(6.1.1) Access to safely managed water (6.2.1) Access to safely managed sanitation (6.4.1) Water use efficiency (6.4.2) Share freshwater withdrawal to available freshwater		(6.1.1) Access to safely managed water (6.2.1) Access to safely managed sanitation	(6.4.2) Freshwater withdrawal (m3/capita/year)
Goal 7: Ensure access to affordable, reliable, sustainable and modern energy for all	(7.1.1) Access to electricity (7.1.2) Access to clean fuels/technology (7.3.1) Ratio of total primary energy supply to GDP (7.2.1) Share of renewable to total final energy consumption		(7.1) Access to electricity	(7.2.1) Share of renewable energy supply (of total energy supply) (7.3.1) Energy use (kg of oil equivalent) per USD 1,000 GDP (constant 2011 PPP)
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	(8.4.1) Material footprint per capita (8.4.2) Domestic material consumption per GDP (8.6.1) Youth not in education, employment or training (8.10.2) Ratio of female to male with financial account	(8.9.2) Tourism and recreation in coastal and marine areas	(8.4.1) Total material footprint per capita	

Goal	Green Growth Index		Green Economy Progress Index and Dashboard	
	SDG indicators	Related to SDG indicators	SDG indicators	Related to SDG indicators
Goal 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation	(9.c.1) Share of population with mobile cellular subscriptions	(9.2.2) Share of green employment in manufacturing		
Goal 10: Reduce inequality within and among countries		(10.1.1) Inequality in income based on Atkinson		(10.1.1) Palma ratio (10.4.1) Proportion of population receiving pension
Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable	(11.1.1) Proportion of urban population living in slums (11.6.2) PM2.5, mean annual population-weighted exposure	(11.6.1) Municipal solid waste generation per capita	(11.6.2) PM2.5, mean annual population-weighted exposure	
Goal 12: Ensure sustainable consumption and production patterns	(12.2.1) Material footprint per capita (12.2.2) Domestic material consumption per GDP	(12) Share of organic agriculture to agricultural area (12) Adjusted net savings (12) Share of environmental goods to total export (12.a) Share of environmental technology to total patents (12.b) Tourism and recreation in coastal and marine areas	(12.2.1) Material footprint per capita	(12) Share of environmental goods to total export (12.a) Share of patent publication in environmental technology by filing office
Goal 13: Take urgent action to combat climate change and its impacts		(13) CO_2 emissions per capita, excluding AFOLU (13) Non-CO_2 emissions per capita, excluding AFOLU (13) Non-CO_2 emissions in agriculture per capita		(13) Greenhouse gas emissions per capita, excluding land-use change and forestry

Goal	Green Growth Index		Green Economy Progress Index and Dashboard	
	SDG indicators	Related to SDG indicators	SDG indicators	Related to SDG indicators
Goal 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development	(14.5.1) Proportion of marine Key Biodiversity Areas covered by protected areas (14.5.1) Share of marine protected areas to territorial areas		(14.5.1) Share of marine protected areas to territorial areas	(14.3.1) Nitrogen emissions per capita
Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss	(15.1.1) Share of forest area to total area (15.1.2) Proportion of terrestrial and freshwater Key Biodiversity Areas covered by protected areas (15.5.1) Red list index	(15.1.2) Share of terrestrial protected areas to territorial areas (15.3.1) Average soil organic carbon content (15.3.1) Soil biodiversity, potential level of diversity		(15.1.2) Share of terrestrial protected areas to territorial areas (15.3.1) share of land used for permanent crops (land use)
Goal 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels	-	-	-	-
Goal 17: Strengthen the means of implementation and revitalize the global partnership for sustainable development	(17.6.2) Share of population with internet broadband subscriptions			

Note: Numbers in parentheses refer to the SDG Target (two levels) and Indicators (three levels). Source of information as of December 10, 2019: (United Nations, 2019)

3.2.2 Indicator selection

There is a similar approach for choosing indicators for the GG and GEP Indices. Their selection processes were based on: (i) relevance to the green concept they want to measure (which are the four green growth dimensions for the GG Index and Inclusive Green Economy for the GEP Index); (ii) spatial coverage (the target is 140 countries for each indicator for the GG index while the GEP selects them with the objective of having at least 100 countries covered[5]); (iii) time coverage (both the GG and GEP Indices look for data for which time-series is available in order to allow regular updates; and (iv) data accessibility (both indicators used publicly available data). As a result of the similar approach, eight indicators are in common between the GG and GEP Indices including green trade, share of environmental patents, material footprint, protected areas, access to water and sanitation, PM 2.5 air pollution, renewable energy, and income inequality.

The selection of the indicators for the GG Index was guided by four main criteria:

(i) **Relevance of the indicator to the green growth dimensions based on conceptual and empirical evidence**. Literature review was conducted to provide evidence on the relevance of the indicators to the green growth dimensions and pillars. Some of the indicators are, however, "proxy variables" because the desired ones are either not available or have dearth of data.

(ii) **Coverage of more than 140 countries that include a large number of GGGI member and partner countries**. The great majority of the 36 GGI indicators meet the requirement of having wide data coverage of number of countries and years. As an exception, two indicators which did not meet these criteria were included because of their relevance, i.e. share patent publications in environmental technology to total patents for green economic opportunities and share of youth (aged 15-24 years) not in education, employment or training for social inclusion. Both indicators have data for less than 100 countries. No alternative (i.e. proxy) data is currently available for these indicators, but indicators for social inclusion are expected to improve in the next years because they are SDG indicators.

(iii) **Availability of time-series data to allow updates of the Index on a regular interval.** Most of the indicators included in the GG Index have available data for several consecutive years. However, two indicators in efficient and sustainable resource use (i.e. water use efficiency; average soil organic carbon content) and natural capital protection (i.e. municipal solid waste [MSW] generation per capita; soil biodiversity, potential level of diversity living in soils), and one indicator for social inclusion (i.e. proportion population above statutory pensionable age receiving a pension) have data only for one year.[6]

(iv) **Accessibility of the data to allow replication of methods and credibility of their sources to enhance acceptability of the data**. Data for all indicators that were included in the GG Index are publicly available online (Acosta, Maharjan, et al., 2019). The data were mainly collected from international organizations, which offer important advantages for measuring performance across countries.

To decide which indicators should be included in the GEP Measurement Framework, four selection criteria were also used:

(i) The first was to identify indicators related to the challenge that an Inclusive Green Economy seeks to address and/or a category of the new generation of capital. The indicators should capture policy outcomes in areas in which policymakers could invest more resources to green their economies and make them more inclusive (e.g. access to basic services).

(ii) The second was on data coverage. For indicators to be useful in comparing the progress made by countries in greening their economies, indicators must be adequate in terms of country development (developed and developing) and time coverage (with information for countries from all regions/degree of development, and with observations over a period of at least two years). The two years considered in the GEP Index in this initial instance are 2004 and 2014, and the data is averaged over a five-year period around these years. This approach was chosen based on availability of comparative data and because it takes time for green economy indicators to fully reflect policy changes. For the sake of simplification, the averaged data over 2000-2004 are referred to as "2004" and the averaged data over 2010-2014 are referred to as "2014" in this report. The temporal frame can be updated as more data becomes readily accessible. Indicators that fulfil the first selection criterion and for which there is good data coverage were preferred.

[5] The fact that the GEP is about changes over time imposes more pressure on the availability of data, thus has a less ambitious target on country coverage.

[6] The GGGI team expects to replace such indicators with more available data in the next versions of the index. Most of the indicators with data availability limited to one year are proxy variables and expected to be replaced by more desired data in the next years. For example, FAO is currently finalizing its database for soil nutrients (alternative data for soil organic content) and soil biodiversity. Further improvements are also expected in data for water use efficiency and statutory pensions as they are SDG indicators.

(iii) The third was on data access. Data should be publicly available through international organizations with the mandate of collecting and harmonizing global databases and, in some cases, from NGOs with excellent records of accomplishment in the regular production of indicators (e.g. the World Resource Institute and the Global Footprint Network). This will allow the results of the GEP Index to be replicated, tested, and expanded.

(iv) The fourth and final criterion, which was applied solely to the indicators in the Dashboard of Sustainability, was that they should be widely recognized as representing a planetary boundary (e.g. land, water, emissions) and have an estimated threshold value derived from the literature.

It is important to note that it was not possible to include very relevant indicators for the GG and GEP Indices. For example, GEP Index was not able to include indicators for green jobs because they were still at a preliminary stage of development during the development process and for renewable energy investments because data are proprietary. For the GG Index, several indicators for the 2019 results were based on proxy variables because data were insufficient including inadequate housing, waste recycling, water treatment, etc. (Acosta, Maharjan, et al., 2019).

3.2.3 Targets and thresholds

There are two ways to assess similarities in using targets and thresholds in GG and GEP Indices – how they are integrated in the computation of the Index as part of methodology and interpreted as part of the conceptual framework (Table 5).

Table 5. Differences in the integration and interpretation of targets and thresholds in the Green Growth and Green Economy Progress Indices

Aspect	Green Growth Index	Green Economy Progress Index
Definition	Sustainability targets for each indicator which country aim to achieve green growth. No specific threshold, but lower bound value of 1, implying target is not achieved.	Targets refer to desired changes (aspirational values), and thresholds define the critical levels that should not be surpassed for each indicator.
Integration	Integrated in the re-scaling method to compute normalized scores of the indicators (equation 2).	Integrated in the calculation of first set of weights ($\hat{\pi}$) in equation 3.
Interpretation	It measures distance to target. Score of a normalized indicator ranges from 1 to 100, where 100 imply sustainability target was achieved for this indicator.	It provides weight on the progress, giving more weight on indicator with lower initial value. Critical threshold was achieved if weight is 1 and has been exceeded if it is above 1.

With regards to the methodology, both the GG and GEP Indices include target values to measure the countries' performance and progress. Such values are referred to as *sustainability targets* in the GG Index and *critical thresholds* in the GEP Index. Some of the targets/thresholds identified for the indicators have the same interpretation in both Indices: this is the case for material footprint, air pollution and protected areas, where the sustainability target/critical threshold is a minimum standard for both methodologies. However, for the rest of indicators, the GG Index's sustainability targets are aspirational levels that countries should aim to achieve, while for the GEP framework they are, as a general rule, minimum sustainability values. Yet, GEP Index's critical thresholds (which are calculated with a data-driven approach) could become aspirational values for those countries where a target is not ambitious enough. In those cases, for the GEP index, the thresholds would also work as an aspirational target, as in the case of the GG Index.

With regards to the frameworks, GG and GEP Indices have an analogous interpretation of the sustainability targets and critical thresholds (Table 5). For the GG Index, a country achieving the sustainability target should have a score of 100. In policy terms, this means that a country that reaches its sustainability value achieves the highest possible performance and cannot increase further. In the GEP Index's framework, critical thresholds are used to determine the weights rather than the scores. As elaborated below, GEP's first weights measure countries' initial conditions with respect to the target. A country that achieved (or exceeded) the critical threshold will have a first weight equal (or above) 1, which indicates that progress on this indicator is relatively inadequate. This methodological analogy suggests that we should expect a high degree of coincidence, among countries, within the indicators reaching 100 in the GG Index and the weights equal or lower than 1 in the GEP Index. If this is the case, this would provide evidence on the common interpretation of the sustainability targets and critical thresholds in both frameworks.

Sustainability targets in the GG Index are aligned as much as possible to the SDG targets. For the SDG targets, the reference year is 2030 (except for share of marine biodiversity, for which the reference is 2020). Many countries have already achieved the 2030 targets for the SDG indicators.

The criteria for selecting the sustainability targets are based on the following:

i. For SDG indicators, use SDG targets (explicit and implicit) suggested in the reports of the OECD (2019) and Sustainable Development Solutions Network (Sachs, Schmidt-Traub, Kroll, Lafortune, & Fuller, 2019). If interpretation of the implicit targets is different, adopt the SDSN values which are applied on a global context;
ii. For non-SDG indicators, use targets suggested in scientific literature and reports from international organizations;
iii. For SDG indicators not included in the OECD (2019) and SDSN (Sachs et al., 2019) reports, use mean of top 5 performers; and
iv. For non-SDG indicators with no available information from literature and reports, use mean of top 5 performers

Critical thresholds in the GEP Index are analogous to GG Index's sustainability targets. In addition to the thresholds, GEP Index uses aspirational values (also referred to as targets) that countries should aim to achieve. According to the distribution of the variables across Human Development Index (HDI) groups, GEP Index's thresholds can substitute the targets for those countries where a given target is not ambitious enough. Critical thresholds were determined based on the data and internationally recognized scientific sources. For "goods" ("bads"), the value of the threshold was set at the value of the 25th (75th) percentile of the distribution in 2004. Countries should never go below (or above) the value achieved by the bottom 25% (top 75%) of countries in 2004 for this indicator. Internationally recognized scientific sources were used for environmental indicators, including recommendations on air pollution from the World Health Organization (WHO, 2005), material footprint per capita from (Bringezu, Schütz, Steger, & Baudisch, 2004), and protected areas from Aichi Biodiversity Targets (Leadley et al., 2014).

GEP Index's targets (or aspirational values) were determined based on data distribution of the indicators (PAGE 2017b, p.25): "For a 'good', the target of a country is calculated on the basis of the 10 percent best performing countries in the distribution. For a 'bad', the target of the country is set to achieve a reduction as significant as the reduction of the 10 percent best performing countries in the relevant comparison group." However, data-driven methodology may indicate (for some indicators and for some countries) aspirational values that are not ambitious enough (for example, when the 10 percent best performing countries in the HDI group perform worse than the 10 percent best performing in the whole distribution, or when the threshold resulting from the calculations is lower than the critical target).[7] GEP methodology considers this as incorrect or inappropriate values. In such case, the highest (lowest) target values for goods (bads) are chosen from one of the following three values:

i. a performance increase that is at least as good as the one achieved by the 10 percent best performing countries in the HDI comparison group;
ii. a performance increase that is at least as good as the one achieved by the 10 percent best of the entire distribution; or
iii. the critical threshold.

This data-driven approach helps to set targets that are ambitious but feasible according to specific country characteristics of the relevant comparison group.

3.3 Interpretation

The foregoing discussion highlights several outcomes from the different steps of development of the GEP and GG Indices. This section provides a summary of these outcomes and guide for their interpretation in the following empirical assessment.

3.3.1 Performance versus progress

The GG Index measures a country's performance in achieving sustainability targets in the four dimensions of green growth – efficient and sustainable resource use, natural capital protection, green economic opportunities, and social inclusion. For the GG Index, assigning a lower bound equal to 1 and integrating sustainability targets in the normalization process result in normalized scores ranging from 1 to 100, where 100 implies reaching the target for the indicator. This provides a clear-cut interpretation of the results from three level aggregations in terms of a country's performance relative to distance from the target:

- 80-100 are very high scores, having reached or almost reached the target;
- 60-80 are high scores, taking a strategic position to completely reach the target;
- 40-60 moderate scores, finding the right balance to move forward to and avoid moving away from the target;
- 20-40 low scores, getting right policies to align development to achieving the target;
- 1-20 very low scores, requiring significant actions to improve position relative to the target.

[7] See PAGE (2017). Green Economy Progress Measurement Framework – Methodology for a detailed description of the methodology for calculating the thresholds.

Out of the 36 indicators, 58% have positive (e.g. water use efficiency, share of forest area to total area) and 42% have negative (e.g. share freshwater withdrawal, PM2.5 air pollution) relationship to green growth. The normalization method applied an inverted equation for the latter indicators, transforming all normalized indicators to have positive relationship to green growth.[8] Thus, the above interpretation applies not only to normalized indicators, but also to the results from all levels of aggregation including indicator categories (level 1), dimensions (level 2), and GG Index (level 3).

For the GEP Index, results from different steps have different interpretation – progress (P), first weight $\hat{\pi}$), and second weight (π). Progress (P) is a measure of performance in indicators, both "goods" and "bads", during two time periods. Goods are indicators with positive and bads are those with negative relationship to green economy. In the GEP framework, they are interpreted as follows (PAGE 2017b, p.11): an increase in the amount of a "good" will increase progress, while an increase in the amount of a "bad" will decrease progress (or increase "regress"). When calculating progress (P) for individual indicators, the goods and bads were differentiated from each other. At this step, the initial (2004) and actual (2014) values and some desired values (target) of the indicators were considered, but not the weights.[9] The weights from equations 3 and 4 were the required steps to aggregate the indicators into GEP Index. The progress (P) is interpreted according to two features: first, it takes a value above or below one, where above 1 refers to progress above the target and below 1 refers to progress below the target; and second, it is positive if there is a progress and negative if there is regress.

The interpretations of the weights are as follows:

- First weight ($\hat{\pi}$) indicates how far off a country is from an indicator's critical threshold and how much progress is needed to achieve sustainability in green economy.
- Second weight (π) informs about the importance of indicators relative to each other and helps in setting priorities for policy.

3.3.2 Scores and ranks

The use of scores and ranks are quite straightforward for the GG Index. The scores, which range from 1 to 100, were generated from the geometric aggregation of the green growth dimensions (level 3 of aggregation). The country ranks are based on these scores, where the highest is assigned the first rank. The country occupying the first rank has the closest distance to the green growth target.

In the GEP framework, ranking is based on a protective criterion (GEP+), which takes into consideration both the GEP Index and the Dashboard of Sustainability indicators. The GEP Index is the weighted average of second weights with scores ranging from 1 to -1, where 0 means no progress, positive values providing progress level, and negative values providing regress level. The Dashboard provides progress (P) for each indicator of the planetary boundaries, with positive values above or below 1 indicating progress above or below the target and negative values above or below 1 indicating regress above and below the target. The protective criterion selects one that provides the best score from the following: (1) for the "goods", highest progress (P) from the dashboard; for the "bads", (2) highest regress from the dashboard and (3) highest GEP Index. The country ranks are based on the GEP+ scores (protective criterion), where the highest is assigned the first rank. The countries occupying the highest ranks made an important progress in Green Economy without surpassing the planetary boundaries and thus compromising future well-being.

[8]Refer to section 5.6 of the Green Growth Index: Concept, Methods and Applications for methods on normalization on pages 37-39 (Acosta, Maharjan, et al., 2019).

[9]Refer to section 3.1 of the Green Economy Progress Measurement Framework – Application for a detailed description of the methodology for calculating Progress for single indicator (PAGE, 2017a).

04 EMPIRICAL ASSESSMENTS

4.1 Different indicators

4.1.1 Key findings from global indices

Three key findings are presented for global results from GG and GEP Indices – global Index maps, dashboard of indicators, and country ranks (top 4) per HDI groups.

Global Index maps

Figure 5 presents GG Index for 115 countries that received scores for all four green growth dimensions for 2019.[10] The scores range from 1 to 100, with 1 having the lowest or very low performance and 100 having the highest or very high performance. Because the indicators are benchmarked against sustainability targets (i.e. SDGs, other globally agreed targets, and top 5 country performers), a score of 100 means that a country has reached a given target. The scores for the 2019 Index range from very low to high, with no countries reaching a very high score. The 23 countries with high scores are all in Europe. Fifty-two countries have moderate scores on green growth performance and 38 countries have low scores. A large number of countries in the Americas have moderate green growth performance. The low performing countries are mainly in Africa (12 countries) and Asia (15 countries). Two countries have very low scores for the GG Index including Sudan in Africa and Iraq in Asia. The top-ranking countries in each region include Botswana in Africa, the Dominican Republic in the Americas, Singapore in Asia, Denmark in Europe, and New Zealand in Oceania.

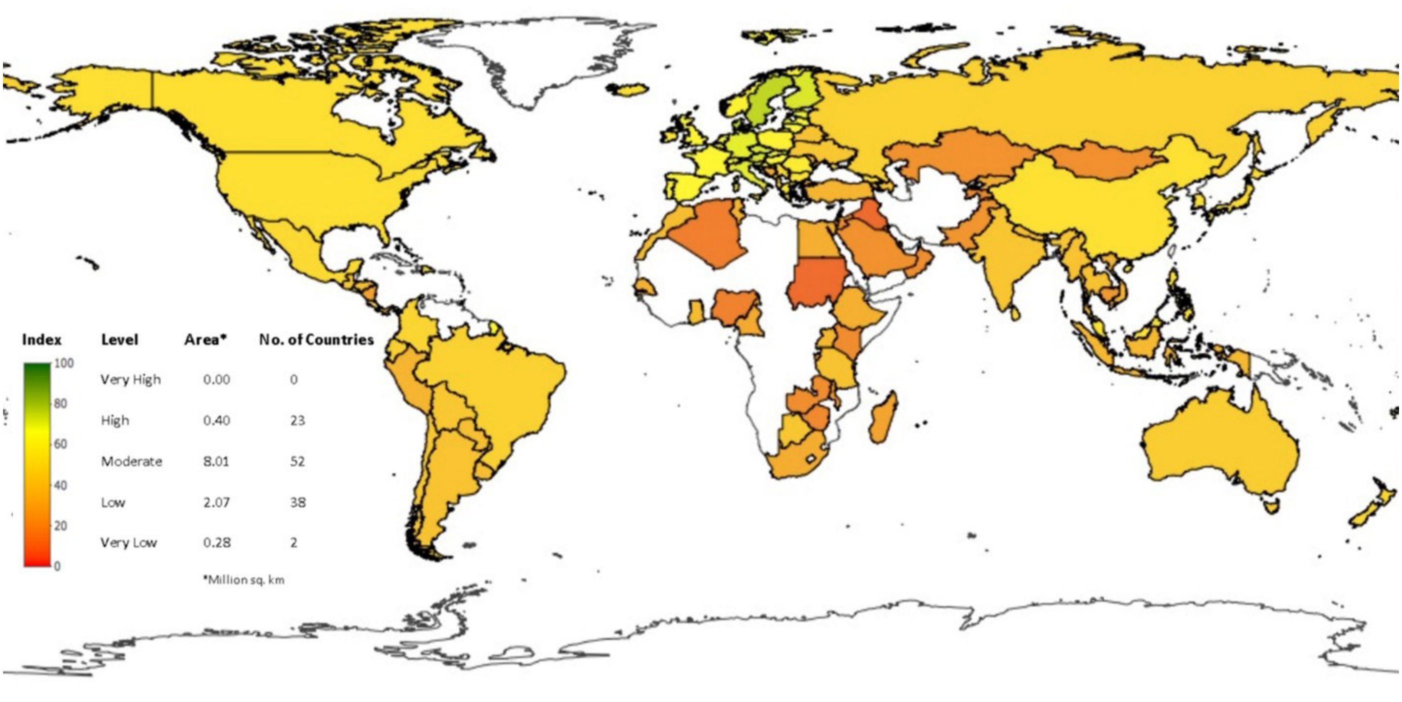


Figure 5. Green Growth Index for 115 countries, 2019
Source: Green Growth Index - Concepts, Methods and Applications (Acosta, Maharjan, et al., 2019)

The GEP Index for 2017 presents results for 105 countries for the two data points of analysis, 2004 and 2014 (taking averages for each indicator between 2000-2004 as the "start" period and averages for indicators between 2010-2014 as the "end" period) (PAGE, 2017a). From a multidimensional perspective of progress, the GEP Index showed that for 2014, 83 out of 105 countries (79%) managed to achieve progress in their transition towards an Inclusive Green Economy, as compared to the year 2004. Figure 6 shows a global map of the GEP Index for 105 countries. The 83 countries that made progress are presented in green. The darker the green area is, the higher the progress on Inclusive Green Economy, as measured by the GEP Index. The 22 countries that experienced regress are presented in red, with the darker red areas indicating countries with the most significant cases of regress. By region, all countries in the Middle East and North African (MENA) and South Asian regions in the sample (6 are MENA and 5 South Asian countries) showed progress. However, the best performing country in Sub-Saharan Africa, Latin America, Europe, and Central Asia and in the Developed country group outperformed the best performer in the Middle East and North African and South Asian regions. The region where most countries experienced regress was the East Asia and the Pacific (EAP) group, where only three out of eight EAP countries in the sample had a positive GEP.

[10] Non-substitutability among dimensions is assumed, so the Index is not computed if the score for one dimension is missing.

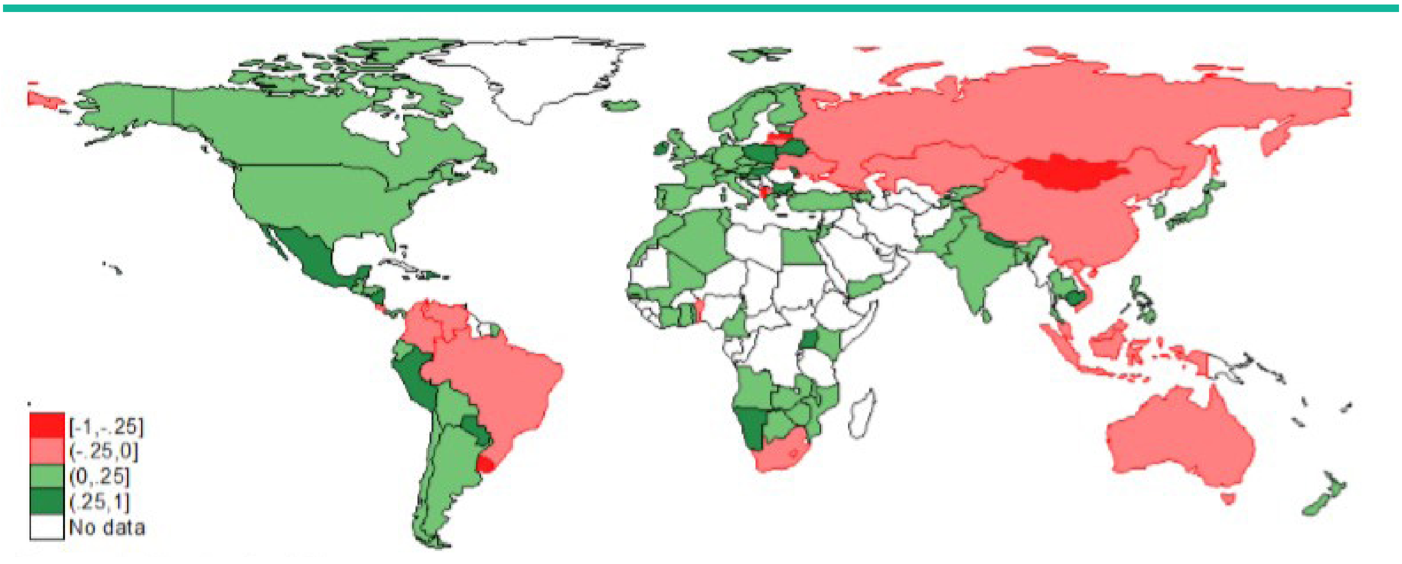


Figure 6. Green Economy Progress Index for 105 countries, 2017
Source: The Green Economy Progress Measurement Framework – Application (PAGE, 2017a).

Dashboard of indicators

Figure 7 presents a dashboard for GG Index summarizing the performance on the different indicator categories for each dimension by region. While the dashboard in the GEP Index refers to the indicators representing planetary boundaries, the dashboard in GG Index presents the results at level 1 of aggregation, i.e. combined indicators representing a given green growth pillar (or indicator category). The performance in natural capital protection, particularly environmental quality and GHG emissions reduction, is high to very high in almost all the regions. In contrast, performance in green economic opportunities, particularly in green trade and green innovation, is low to very low in many regions. Europe performs notably better in all indicator categories as compared to the rest of the regions. Many countries in Africa, the Americas, and Asia have rather low performance in sustainable land use. Lack of green trade and innovation is the main constraint to reaching the targets for green economic opportunities across all regions. In addition, poor sustainable land use hinders efforts to improve performance in efficient and sustainable resources use, particularly in many countries in Africa, the Americas, and Asia.

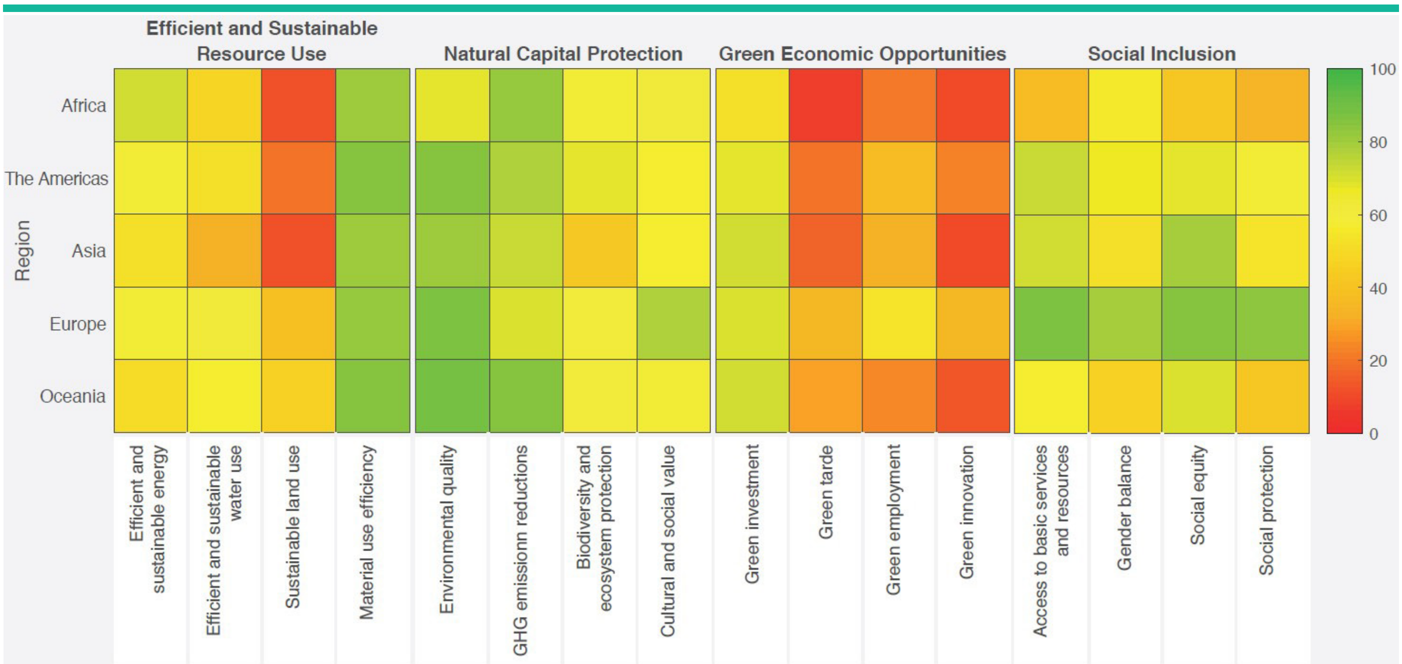


Figure 7. Dashboard of indicator categories in each green growth dimension, by region, 2019
Source: Green Growth Index - Concepts, Methods and Applications (Acosta, Maharjan, et al., 2019)

Although the GEP Index results for 2017 were encouraging, they nevertheless showed the amount of effort still needed to ensure that improving human well-being did not come at the expense of key stocks of capital. Table 6 showed the individual results on the Dashboard of Environmental Sustainability indicators for the 105 countries in the sample.[11] Results revealed that countries were, on average, regressing in their sustainability indicators, i.e. they were surpassing planetary boundaries. The only indicator where majority of countries was making progress was the Inclusive Wealth Index. However, when only considering the natural capital aspect of the Inclusive Wealth Index, results showed that most countries had regressed. In addition, no country was surpassing its target for the greenhouse gas emission reductions (the maximum value achieved by the countries was below 1), an area of significant concern given the impact of these emissions on global environmental sustainability. Overall, results on the GEP dashboard indicators showed major heterogeneities between regions and across indicators. While countries were improving their well-being in relation to economic opportunities, social inclusiveness, and environmental protection (i.e. positive GEP as shown in Figure 6), the improvement was not sustainable in the long run as it come at the expenses of the key stock of capital (Table 6).

Table 6. Summary of dashboard indicators (includes only countries with GEP Index), 2017

Indicator	Obs	Mean	Std. Dev.	Min	Max
Freshwater withdrawal	79	-0,07	1,65	-10,93	1,28
Greenhouse gas emissions	104	-0,31	0,68	-3,74	0,84
Emission of Nitrogen	102	-0,35	1,11	-5,07	1,48
Land use	104	-0,31	1,03	-4,24	1,54
Ecological Footprint	92	-0,34	0,82	-4,95	1,02
Inclusive Wealth Index	100	0,31	0,52	-1,11	1,84
Inclusive Wealth Index (Natural Capital)	100	-5,84	7,48	-26,41	5,21

Source: The Green Economy Progress Measurement Framework – Application (PAGE, 2017a).

Country ranks (top 4) per HDI groups

Table 7 presents the country ranks for the GG Index based on four HDI groups – very high, high, medium, and low HDI. The top four countries belonging to very high HDI group include Denmark, Sweden, Austria, and Finland. These four European countries are also the top four countries globally, i.e. not taking into account any country groupings. The scores of Denmark and Sweden are, however, very close to each other, with Denmark significantly exceeding the scores of Sweden only in green economic opportunities. The top four countries among high HDI group include Georgia, China, Sri Lanka, and Mexico. Except for Mexico, all countries are in Asia. Mexico has the highest score for natural capital protection among the four countries in this HDI group. Its score for this dimension is higher than the scores of top four countries in Europe. The Philippines, Dominican Republic, El Salvador, and Guatemala are the top four countries in medium HDI group. Except for the Philippines, all countries are in the Americas. The Dominican Republic ranks 1st in GG Index and has the second highest score for natural capital protection in this region. The top four among countries with low HDI are from the African region – Uganda, Senegal, Madagascar, and Malawi (for comparative analysis, Tanzania and Ethiopia were excluded from the analysis because they do not have GEP Index). These countries have low to very low scores in green economic opportunities and social exclusion.

For the GEP Index, Table 8 presents the results for the first four countries by HDI group, which is the most valid way of comparing the countries performances due to the methodology used for selecting the aspirational (or target) values.[12] Among the very high HDI Group, Cyprus had the highest rank, followed by Portugal, Spain, and Italy. All four countries showed progress in the dashboard and the GEP Index, indicating to be on a path to sustainable development. For Cyprus, Spain, and Italy, the value on land use was the lowest. In the case of the high HDI group, Jamaica was the country with the highest ranking because it was the only country in this group with all indicators demonstrating progress. Azerbaijan, Jordan, and Venezuela ranked immediately after, with lowest score in greenhouse gas emissions. For the medium HDI group, there was no country with progress in all indicators, but Dominican Republic was the top ranked country because its regress on greenhouse gas emissions was the smallest in all indicators that experienced regress for countries in this group. Finally, for the low HDI group, Zimbabwe was the country with the highest ranking, the only country in this group with all indicators showing positive or zero progress. The rest of the countries in all HDI groups have experienced regress in at least one indicator.

[11] Note that these results are shown by completeness, but the common application will not have indicators belonging to the dashboard (only to the GEP index).

[12] The target determined for each country depends on the progress achieved by the 10 per cent best performing countries in the relevant comparison group (e.g. countries with similar human development according to the Human Development Index).

Table 7. Ranks on Green Growth Index and scores on dimensions (Top 4 countries per HDI group)

Rank	Country*	Efficient Sustainable Resource Use	Natural Capital Protection	Green Economic Opportunities	Social Inclusion	GG Index	HDI Group
1	Denmark	75.50	72.52	63.84	92.07	75.32	Very High
2	Sweden	75.79	77.26	57.96	93.70	75.09	Very High
3	Austria	71.57	79.56	52.27	91.92	72.32	Very High
4	Finland	67.36	72.25	58.86	92.23	71.69	Very High
1	Georgia	50.00	72.46	37.19	70.17	55.45	High
2	China	34.49	70.15	55.41	70.32	55.41	High
3	Sri Lanka	60.97	69.67	33.42	54.49	52.74	High
4	Mexico	37.70	77.36	40.70	65.03	52.71	High
1	Philippines	46.48	70.62	48.34	59.96	55.54	Medium
2	Dominican Republic	55.89	81.28	31.56	64.30	55.10	Medium
3	El Salvador	42.96	66.84	44.84	65.76	53.94	Medium
4	Guatemala	52.46	73.20	23.56	52.90	46.77	Medium
1	Uganda	47.04	75.70	27.10	29.18	40.96	Low
2	Senegal	32.14	71.39	22.71	40.73	38.17	Low
3	Madagascar	43.98	62.65	18.31	25.85	33.79	Low
4	Malawi	37.72	84.55	9.63	24.44	29.43	Low

*Note: For comparative purposes, Tanzania (rank 1) and Ethiopia (rank 2) were not included in the low HDI group because they are not part of the GEP Index.
Source: Authors' calculations

Table 8. Rank GEP Index-dashboard profiles using the Protective Criterion (Top 4 countries per HDI group)

Rank	Country	Progress			GEP Index	Protective criterion	HDI group
		GHG Emissions	Nitrogen Emissions	Land Use			
1	Cyprus	0,5566	0,5971	0,1800	0,5862	0,1800	Very High
2	Portugal	0,9080	0,7315	0,1120	0,0999	0,0999	Very High
3	Spain	1,3180	1,7082	0,0873	0,2118	0,0873	Very High
4	Italy	0,9423	1,9024	0,0664	0,2598	0,0664	Very High
1	Jamaica	1,1022	0,4906	0,1682	0,1256	0,1256	High
2	Azerbaijan	-0,1942	0,0018	0,0010	0,2512	-0,1942	High
3	Jordan	-0,2369	2,1228	0,0080	0,1523	-0,2369	High
4	Venezuela	-0,3027	0,3700	0,0227	-0,0497	-0,3027	High
1	Dominican Republic	-0,2539	-0,2341	0,0000	0,2801	-0,2539	Medium
2	South Africa	-0,3429	0,6564	-0,0059	-0,1977	-0,3429	Medium
3	Philippines	0,1430	0,3621	-0,3572	0,1978	-0,3572	Medium
4	Honduras	-0,3793	0,6753	-0,1613	0,1329	-0,3793	Medium
1	Zimbabwe	0,9104	0,2037	0,0000	0,0530	0,0000	Low
2	Senegal	0,2000	0,0080	-0,0052	0,1607	-0,0052	Low
3	Cameroon	0,8613	0,0657	-0,1058	0,2448	-0,1058	Low
4	Mali	-0,1776	1,7463	-0,0061	0,1931	-0,1776	Low

Source: The Green Economy Progress Measurement Framework – Application (PAGE, 2017a).

To sum up the above, the highest performing countries in GG Index with very high HDI are not those with the highest progress in GEP Index. This trend also holds for countries with high HDI. For countries with medium HDI, the Philippines and the Dominican Republic have high green growth performance, this performance will likely to continue in the future. These two countries have one of the highest GEP Index, indicating progress in Green Economy. Finally, Senegal has the second highest score for both GG and GEP Indices among countries with low HDI.

4.1.2 Case studies: China and Mexico

This section presents detailed results on the Index and indicators as well as the performance and progress in achieving targets for China and Mexico. The results for the GG Index show that China has slightly better green growth performance than Mexico in 2019. In terms of performance in green growth dimensions, both have performed relatively well in natural capital protection and social inclusion, with Mexico performing slightly better than China for most indicators in natural capital protection. Mexico performed better than China in achieving progress toward a sustainable inclusive Green Economy. Moreover, Mexico improved its performance for the indicators where progress was needed and, over time, progressively moved in the right direction to surpass critical thresholds.

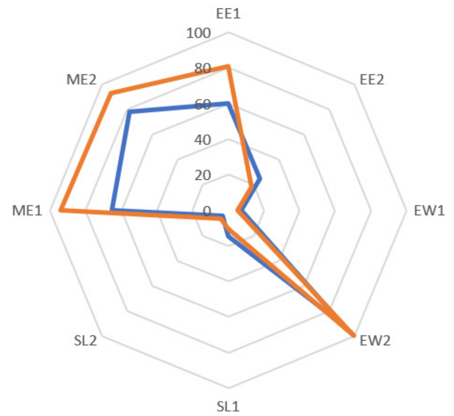
Green Growth Index

Indicator scores: Figure 8 presents the scores for the indicators in each green growth dimension for China and Mexico. For efficient and sustainable resource use dimension, Mexico performs better than China in domestic material consumption per GDP, material footprint per capital, ratio of total primary energy supply to GDP, and share of freshwater withdrawals. Mexico has very high scores for all these four indicators. Both countries have low and very low scores for share of renewables, water use efficiency, soil organic carbon content, and share of organic agriculture. After green economic opportunities, performance in efficient and sustainable resources is lowest among the four green growth dimensions for both countries. For green economic opportunities, China performs better in almost all four indicators, except for share of export of environmental goods. China's score for green investment, as represented by adjusted net savings, is very high at about 80. Green employment is another indicator where China excels, with a high score of over 75. The lowest score for Mexico for the green economic opportunities dimension is for share of patent publications in environmental technology with score of less than 20.

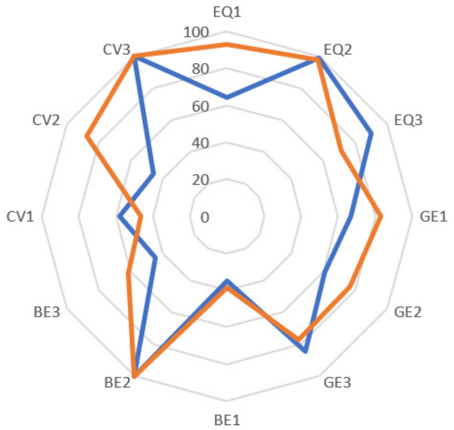
Scores for natural capital protection dimension range from high to very high for many indicators for both China and Mexico. Both countries have very high scores of 100 for DALY rate as affected by unsafe water sources, share of forest area to total land area, and share of terrestrial and marine protected areas to total territorial areas. China performs better than Mexico in indicators for municipal solid waste generation per capita and Red List index, while vice versa for tourism and recreation in coastal areas, PM.25 air pollution, CO2 and non-CO2 emissions per capita, and soil biodiversity. The largest divergence in scores between the two countries is for tourism and recreation in coastal areas and PM.25 air pollution. After natural capital protection, scores are highest for indicators in social inclusion for both China and Mexico. China has very high score of 100 for the proportion of population above statutory pensionable age receiving a pension and ratio of urban-rural access to basic services, while Mexico has 100 score only for the latter. But Mexico significantly exceeds the scores of China for the proportion of seats held by women in national parliaments as well as laws and regulations for equal gender pay. Overall, the two countries outperform each other in different indicators, with China performing better than Mexico in green economic opportunities social inclusion. But Mexico performs much better than China in efficient and sustainable resource use and slightly better in natural capital protection.

Countries: China Mexico

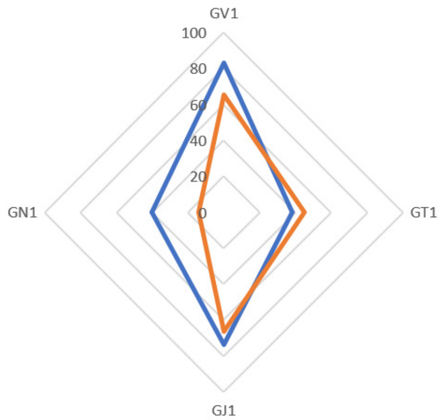
Name of Indicators



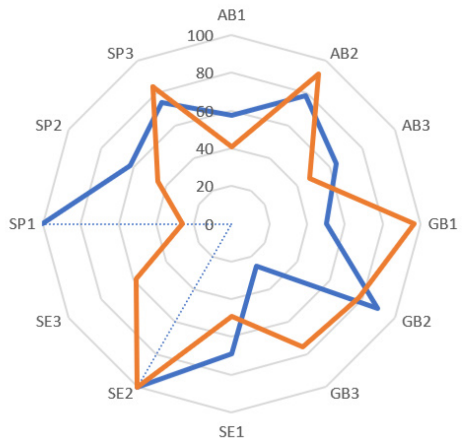
Efficient and sustainable resource use
EE1: Energy intensity (primary energy)
EE2: Share of renewable to total final energy consumption
EW1: Water use efficiency
EW2: Share of freshwater withdrawals to available freshwater resources
SL1: Average soil organic carbon content
SL2: Share of organic agriculture to total agricultural land area
ME1: Total domestic material consumption (DMC) per unit of GDP
ME2: Total material footprint (MF) per capita



Natural capital protection
EQ1: PM2.5, measured as mean annual population-weighted exposure
EQ2: Disability-Adjusted Life Years (DALY) rate as affected by unsafe water sources
EQ3: Municipal solid waste (MSW) generation per capita
GE1: Ratio of CO_2 emissions excl. AFOLU to population
GE2: Ratio of non-CO_2 emissions excl. AFOLU to population
GE3: Ratio of non-CO_2 emissions in Agriculture to population
BE1: Average proportion of Key Biodiversity Areas in protected areas
BE2: Share of forest area to total land area
BE3: Soil biodiversity, potential level of diversity living in soils
CV1: Red List index
CV2: Tourism and recreation in coastal and marine areas
CV3: Share of terrestrial and marine protected areas to total territorial areas



Green economic opportunities
GV1: Adjusted net savings, minus natural resources and pollution damages
GT1: Share of export of environmental goods (OECD and APEC class.) to total export
GJ1: Share of green employment in total manufacturing employment
GN1: Share of patent publications in environmental technology to total patents



Social Inclusion
AB1: Population with access to safely managed water and sanitation
AB2: Population with access to electricity and clean fuels/technology
AB3: Fixed Internet broadband and mobile cellular subscriptions
GB1: Proportion of seats held by women in national parliaments
GB2: Share of females to males with account in financial institution
GB3: Getting paid, laws and regulations for equal gender pay
SE1: Inequality in income, based on Atkinson
SE2: Ratio of urban-rural access to basic services
SE3: Share of youth not in education, employment or training (Note: 0 = no data)
SP1: Proportion of population above statutory pensionable age receiving a pension
SP2: Healthcare access and quality index
SP3: Proportion of urban population living in slums

Figure 8. Scores of indicators for the green growth dimensions for China and Mexico
Source: Authors' calculations

Distance to targets: Figure 9 shows that both China and Mexico are only about halfway to achieving sustainability targets with GG Index scores of 55.41 and 52.71, respectively. Both countries occupy rank 5 in their respective regions in Asia and the Americas. China performs best in achieving targets for green investment, environmental quality, and social equity. With a very high score of 83.11 in green investment, in addition to a high score in green employment, China has the highest score for green economic opportunities in Asia. Although China performs better than Mexico in social inclusion, it only occupies 12th highest score for this dimension in Asia (note, the score excludes Hong Kong China SAR, which is ranked separately). China's lowest green growth performance is evident in sustainable land use. For Mexico, best performances are for material use efficiency, environmental quality, and gender balance. However, despite a very high score of 93.55 for this indicator, the overall score of Mexico for efficient and sustainable resource use is only 37.70 due to very low scores for sustainable land use and moderate scores for efficient and sustainable energy and water use. Mexico's overall score for natural capital protection is 77.47, the 7th highest score for this dimension in the Americas. Among the four green growth dimensions, Mexico has the lowest score for green economic opportunities with a score of only 40.70. Nonetheless, this score is the 3rd highest score in the Americas.

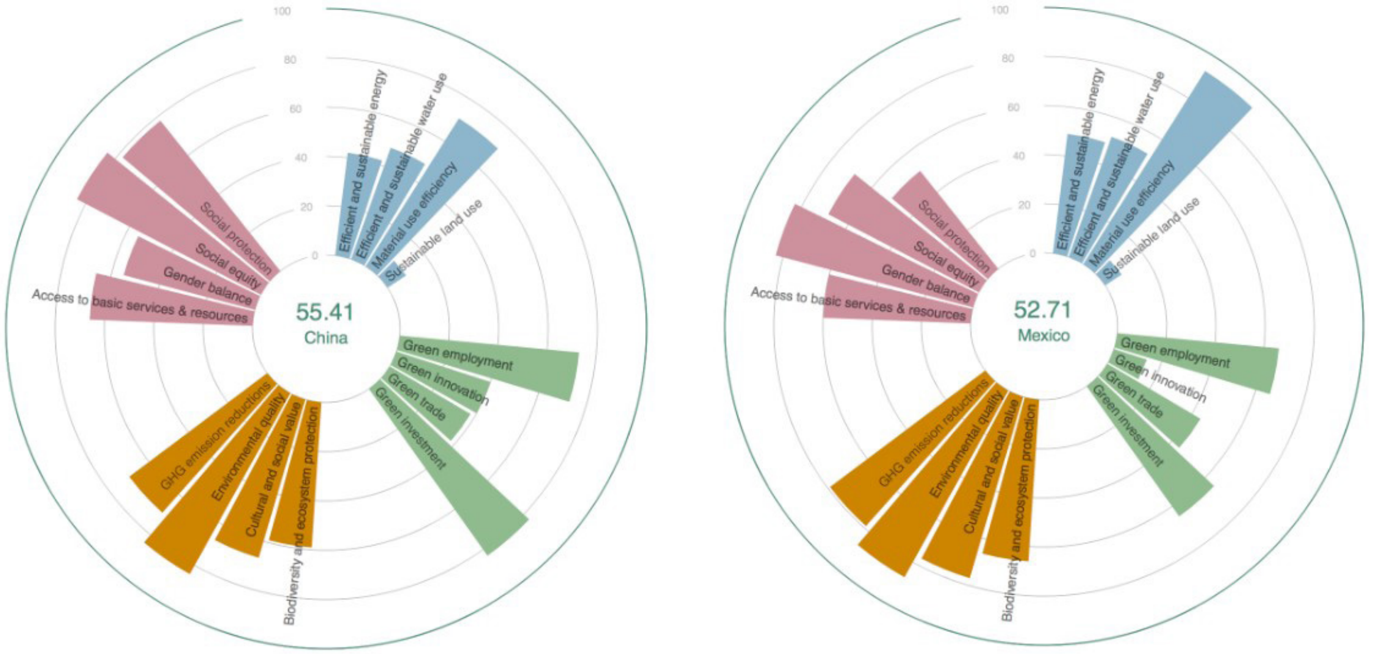


Figure 9. Distance to targets for China and Mexico, by indicator categories
Source: Green Growth Index - Concepts, Methods and Applications (Acosta, Maharjan, et al., 2019)

Green Economy Progress Index

Indicator Progress (P): The GEP measurement framework offers the possibility of analyzing the results not only at the aggregate level (using the index and the dashboard) but also at the level of the individual indicators that capture specific aspects of the transition toward an Inclusive Green Economy. In this regard, a simple way to see whether a country has made progress on an indicator is by reviewing whether the (P) value of the concerned indicator is positive, indicating progress, or negative, indicating regress. For **China**, Table 9 shows that nine out of the 13 indicators experienced progress for the time-period of the analysis (2004 to 2014) including protected areas, energy use, green trade, environmental patent, gender inequality access to basic services, mean years of schooling, pension coverage, and life expectancy. The value of the indicator is higher than 1 for gender inequality, which is the single indicator where the progress achieved exceeded its target value. All the other positive indicators exhibit progress below 1, indicating that the improvement was insufficient to achieve the target. Results also showed that China experienced regress in material footprint, air pollution, share of renewable energy, and income inequality (as measured by the Palma ratio).

For **Mexico**, results showed that the country is on average achieving progress toward a sustainable inclusive Green Economy. Indeed, the GEP Index, which reflects the weighted progress achieved by countries with respect to targets across a combination of social, economic, and environmental indicators, is positive (0.25). There was progress in 10 out of 13 indicators including material footprint, air pollution, protected areas, green trade, environmental patents, gender inequality, access to basic services, education, pension coverage, and life expectancy. In contrast, there was no progress in the use of energy (P = 0). Although Mexico did not achieve its target in any of the indicators (which would be reflected by a progress value higher than 1), two indicators were close to the desired value: share of environmental patents (0.88) and mean years of schooling (0.65). But Mexico experienced a regress on renewable energy and income inequality (measured by the Palma ratio), as shown by the negative values of these indicators (respectively -0.23 and -0.03).

Table 9. GEP Index and progress on individual indicators for China and Mexico, 2004-2014

Indicators	China GEP Index = -0.17			Mexico GEP Index = 0.25		
	Progress (P)	Weights		Progress (P)	Weights	
		π	$\hat{\pi}$		π	$\hat{\pi}$
Material footprint	-3.87	0.07	1.41	0.12	0.15	1.77
Air pollution	-0.16	0.33	6.40	0.03	0.14	1.68
Protected areas	0.04	0.26	5.11	0.18	0.12	1.43
Energy Use	0.52	0.07	1.36	0.00	0.05	0.55
Green trade	0.23	0.01	0.17	0.02	0.01	0.10
Environmental Patent	0.42	0.04	0.69	0.88	0.10	1.18
Renewable energy	-0.51	0.02	0.30	-0.23	0.04	0.44
Palma ratio	-0.19	0.04	0.70	-0.03	0.09	1.01
Gender inequality	1.46	0.03	0.67	0.46	0.07	0.79
Access to basic services	0.64	0.04	0.77	0.33	0.06	0.66
Mean years of schooling	0.36	0.04	0.71	0.65	0.06	0.69
Pension Coverage	0.66	0.01	0.23	0.37	0.05	0.55
Life expectancy	0.41	0.04	0.86	0.35	0.07	0.83

Source: PAGE (2017). The Green Economy Progress Measurement Framework – Application.
Note: π are the weights indicating the distance from the global threshold and $\hat{\pi}$ indicate the relative importance of one component with respect to the others.

Weights ($\hat{\pi}$, π): The calculation of the GEP Index used a weighting system that allows for the assessment of how far off a country is from the global threshold on a specific indicator for Inclusive Green Economy (first weights $\hat{\pi}$) and an evaluation of the relative importance of one indicator with respect to the other indicators from the country's perspective (weights π). For **China**, the results for the first weight ($\hat{\pi}$) showed that nine out of the 13 indicators were within the critical thresholds (Table 9). Specifically, the levels of green trade, share of environmental patents, renewable energy, access to basic service, mean year of schooling, pension coverage and life expectancy were above their critical thresholds; the levels of the Palma ratio and gender inequality were below their critical thresholds. Consequently, the second weights (π), which indicate relative importance among the indicators, were relatively low. In policy terms, this means that, although progress was always beneficial for increasing a country performance toward Green Economy, currently, many of the green economy indicators do not represent policy priorities for China.

With the first weights ($\hat{\pi}$) above 1, the material footprint, air pollution, protected areas, and energy use surpassed their critical thresholds (Table 9). These indicate that, on the one hand, the initial values of "bads" like material footprint per capita, the concentration of particular matters (PM2.5) and the economy's energy intensity were exceeding their critical thresholds (e.g. the initial condition of air pollution is 6.40 times higher than the threshold) and, on the other hand, the "goods" like share of marine and terrestrial protected areas was insufficient to reach the minimum standard. Thus, progress is more urgent for these indicators since these areas are not sustainable under the business as usual scenario, as is suggested by the relative high values of the weights π. Among the indicators whose initial values in 2004 exceeded the critical threshold, two indicators (protected areas and energy use) showed signs of progress, signaling that China is moving to the right direction toward the critical threshold. However, China is showing a regress on the other two indicators (material footprint and air pollution), moving further away from the threshold. The regression in material footprint and air pollution caused the value of the GEP index of China to be negative (-0.17).

For **Mexico**, five indicators exceeded the critical thresholds (i.e. weights [$\hat{\pi}$] were greater than 1) including material footprint, air pollution, protected areas, environmental patent, and Palma ratio (Table 9). These indicate that the initial values of material footprints and air pollution were exceeding their critical thresholds (i.e. material footprint was 1.77 times and air pollution was 1.68 times higher than the thresholds) and those of environmental patents and share of protected areas were insufficient to reach the minimum standard. In contrast, the initial value for income inequality was almost at the threshold value (weight $\hat{\pi}$ is close to 1). The second weights (π) reflect the policy priorities, indicating the indicators which need attention for Mexico to move toward an inclusive green growth and consequently increase its GEP Index. These weights show that the priorities (i.e. weights with higher values) include reducing material footprint and air pollution, and increasing the share of protected areas. Among the five indicators that exceeded the thresholds, four are showing signs of progress including material footprint, air pollution, protected areas, and environmental patent. The Palma ratio, the fifth indicator exceeding the threshold, is showing regress with P value of -0.03. Overall, from 2004 and 2014, Mexico is showing progress on indicators that need to be prioritized.

4.2 Identical indicators

4.2.1 Common application

The common application, which deals with using different methodologies of GG and GEP Indices to the same set of indicators, can provide a clearer comparison of results and policy implication. The similarities in frameworks between the two Indices allow for common application, i.e. criteria for selection of indicators and role of sustainability targets and critical thresholds. The GG and GEP Indices have eight common indicators, several of which have the same sustainability target and critical thresholds.

Common indicators: The eight indicators selected for the common application are green trade, share of environmental patens, material footprint, protected areas, access to water and sanitation, PM 2.5 air pollution, renewable energy, and income inequality.[13] Table 10 presents the description, source, range of coverage and sample for the latest year of observation for these indicators. The table categorizes the indicators according to the four dimensions used in the GG Index (this is not needed for the GEP index, which only has one level of aggregation) to guide the reader on how the indicators relate to this methodology. For the application of the GEP Index, the initial value is 2010 (except for protected areas, which data was only available for 2000), and the latest value after 2015. For the Green Growth Index, the latest value was used for its calculation.

Table 10. Data sources description for the common application

Indicators	Number countries for latest data	Data range	Data source
Efficient and Sustainable Resource Use			
Share renewable to total final energy consumption (percent)	212	1990-2015	World Bank, Sustainable Energy for All (SE4ALL) database from the SE4ALL Global Tracking Framework led jointly by the World Bank, International Energy Agency, and the Energy Sector Management Assistance Program.
Share total Material Footprint (MF) to population (MF tonnes per capita)	174	1990-2015	United Nations Environment Programme: Secretariat of the International Resource Panel (resourcepanel@unep.org)
Natural Capital Protection			
PM2.5 air pollution, mean annual population-weighted exposure (micrograms per cubic meter)	194	1990-2016	Brauer, M. et al. 2016, for the Global Burden of Disease Study 2016
Share of terrestrial and marine protected areas to total territorial areas	210	1990, 2000, 2014, 2016, 2017	World Database on Protected Areas (WDPA) where the compilation and management is carried out by United Nations Environment World Conservation Monitoring Centre (UNEP-WCMC) in collaboration with governments, non-governmental organizations, academia and industry. The data is available online through the Protected Planet website (protectedplanet.net) and UN-GRID (http://geodata.grid.unep.ch/options.php?selectedID=1871&selectedDatasettype=1).
Green Economic Opportunities			
Share environmental export to total export (Percent)	123	2000-2017	Data using UNCOMTRADE based on APEC and OECD classification
Share patent publications in environmental technology to total patents (Percent)	93	1980-2017	WIPO statistics database. Last updated: December 2018
Social Inclusion			
Population with access to safely managed water and sanitation (percent)	117	2000-2015	WHO/UNICEF Joint Monitoring Programme (JMP) for Water Supply, Sanitation and Hygiene (washdata.org). (water and sanitation)
Inequality in income based on Atkinson (Index)	156	2010-2017	UNDP Human Development Data

[13] The inequality index chosen for the common application is the Atkinson Index. The original GEP used instead the Palma Ratio (PAGE, 2017b).

Similar targets and thresholds: Table 11 shows that four of the eight indicators used in the common application share the same threshold and target values. In terms of the GG Index classification, the indicators with the same values are for the efficient and sustainable resource use (i.e. renewable energy and material footprint) and natural capital protection one (i.e. air pollution and protected areas). The targets and thresholds are different for green economic opportunities (i.e. environmental exports and environmental patents) and social inclusion (access to basic services and inequality).

Table 11. Comparison between GG's sustainability targets and GEP's critical thresholds

Indicators	Threshold for GEP	Sustainability target for GGI	Source
Efficient and Sustainable Resource Use			
Share renewable to total final energy consumption	5.42	51.4	Bringezu et al., 2004
Share total Material Footprint (MF) to population (MF tonnes per capita)	5	5	
Natural Capital Protection			
PM 2.5 air pollution, mean annual population-weighted annual exposure (micrograms per cubic meter)	10	10	WHO, 2014
Share of terrestrial and marine protected areas to total areas	13.5	13.5	Leadley et al., 2014
Green Economic Opportunities			
Share environmental exports (Percent)	0.47	13.52	
Share patent pulications in environmental technology to total patent (Percent)	0.01	0.076	
Social Inclusion			
Population with access to safely managed water and sanitation (percent)	57.92	100	
Inequality income based on Atkinson (Index)	28.075	7.96	

Sources: Unless sources are given, thresholds and targets were based on authors' calculations.

It is important to emphasize that GG and GEP Indices have several methodological differences for aggregation process, weighting, rule for missing indicators, etc., which lead to some discrepancies in the results. The reduction in the number of indicators is especially relevant for the GG Index' methodology, which was originally composed of 36 variables. Thus, instead of 3 levels of aggregation, the GG Index common application only consisted of two aggregation levels. The aggregation rule was selected in accordance with the principles of the original GG Index methodology: equal weightings and decreasing the substitutability for the higher level of aggregation. This means that arithmetic mean was adopted at the first step (where indicators were aggregated into dimensions) and geometric mean at the second step (where dimension were aggregated to form the Index). The reduction is less critical for the GEP Index. In terms of missing data, the GG Index allowed for the presence of missing data in not more than one indicator per dimension. Similarly, the GEP was calculated if no more than 2 out of the 8 indicators were unavailable.

Results for common application

Table 12 presents the results for 107 countries for both GG and GEP Indices. For GG Index, global mean is about 50, with the highest score just above 80 in Europe and the lowest score about 17 in Africa. The GEP Index resulting from the common dataset was measured from a sample of 107 countries between 2005 to 2015 (with the latest value after 2015 as the final value). For the GEP Index, global mean is very close to zero, meaning that overall there is no significant progress, since the weighted sum of positive changes in "goods" and negative changes in "bads" compensate the weighted sum of negative changes in "goods" and positive changes in "bads".

Table 12. Comparison of Green Growth and Green Economy Progress Indices, global and by region

Region	Green Growth Index					Green Economy Progress Index						
	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max	GEP>=0	GEP<0
Global	107	47.92	14.56	17.47	80.17	107	-0.01	0.34	-0.87	0.97	-	-
Africa	24	36.12	11.61	17.47	59.57	24	-0.24	0.45	-0.87	0.97	6	18
America	21	44.35	7.98	30.81	56.84	21	0.05	0.30	-0.50	0.72	13	8
Asia	24	42.25	11.32	20.82	60.04	24	-0.06	0.24	-0.69	0.47	9	15
Europe	36	61.74	10.46	40.72	80.17	36	0.13	0.21	-0.28	0.83	27	9
Oceania	2	46.41	7.21	41.31	51.51	2	0.44	0.42	0.14	0.74	2	0

Note: Mean for the GG Index ranges from 1 to 100, where 100 means achieving the target. For the GEP Index, mean ranges from 1 to -1, where positive values are progress and negative values are regress from the threshold.
Source: Authors' calculations

By region, for GG Index, European countries obtained the highest average score of 61.74). Countries of the Americas stand out next to Europe. The average GG Index achieved by American countries is moderate (44.35) and all countries in this region attained comparable scores (i.e. results show a low standard deviation and tight distance between the minimum and maximum values).[14] Collectively, countries belonging to Asia achieved an average GG Index score of 42.25, which is a bit lower than the average for the Americas. But the Asian countries show a more disperse pattern in the region, with scores ranging from lowest score of 20.82 to highest score of 60.04.[15] African countries seem to lag behind as they achieved the lowest average score (36.12) among all regions. Furthermore, it is an African country with the lowest GG Index globally. The deviation in scores between Europe (i.e. the highest scoring region) and Africa (i.e. the lowest performing region) is significant: the minimum value for Europe is higher than the mean score achieved by the African countries. Oceania, which represents the region with the lowest number of countries (only Australia and New Zealand), attained an average GG Index of 46.41.

For GEP Index, on average, countries from Europe, Oceania and the Americas were doing progress (i.e. positive Index). In terms of number of countries, three quarters of the countries in Europe experienced progress (27 out of 36). This is likewise true for 31 of the 21 countries in the Americas. Both the countries of Oceania (New Zealand and Australia) have a positive GEP Index. In contrast, the Asian and African countries were on average experiencing regress (i.e. negative Index). Only 9 of the 24countries in Asia and 6 out of 24 countries in Africa have a GEP Index of zero or higher. The results for Africa were mostly influenced by the significant increase in air pollution, while for Asia they were driven by the increase in both air pollution and material footprint. Interestingly, globally, not only the lowest but also the highest progress was experienced by countries in Africa.

The boxplots of the GG and GEP Indices in Figure 10 provides further information on the distribution of the scores by region. The African countries show a similar pattern where both GG and GEP Indices are below the middle range, which imply very low green growth performance and low progress in green economy. Although the distribution of country scores is more disperse for GG Index than for GEP Index, the scores for both Indices are quite similar in the Americas, i.e. with scores on the middle range. A similar pattern can be observed for the scores in Europe, where they are mostly above the middle range – high green growth performance and high green economy progress for most countries. Only Oceania diverges from this pattern, where current performance in green growth is moderate but progress in green economy is high over time.

[14] The coefficient of variation for the Americas was 0.1799, only higher of the coefficient of variation of Oceania that was 0.1554.
[15] The coefficient of variation for Asia was 0.2679.

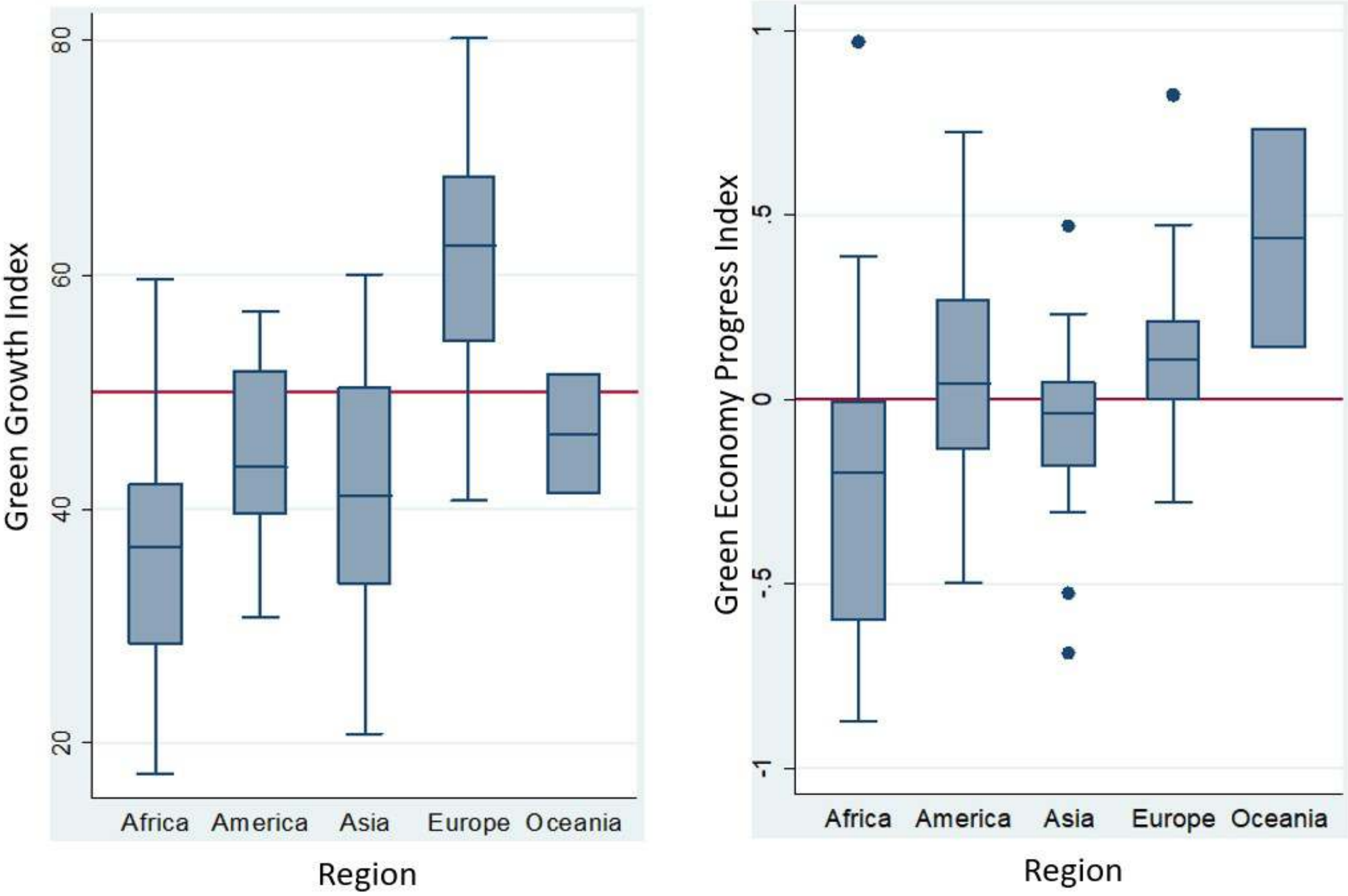


Figure 10. Boxplots of Green Growth Index and Green Economy Progress Index, by region
Source: Authors' calculations
Note: Dots are outliers in the distribution.

Figure 11 presents the GG and GEP Indices by HDI group. Ordering the HDI groups from very high to low, the figure shows a clear descending trend in the average GG Index, i.e. countries with high HDI have high average Index and those with low HDI have also low average Index. However, globally, the highest scoring country (i.e. above 80) is in high (not in very high) HDI group and lowest scoring country (i.e. below 20) is in medium (not in low) HDI group. For the GEP Index, results are similar with GG Index which show a positive correlation between HDI groups and progress in GEP, i.e. higher average GEP scores are associated with higher HDI level. Specifically, countries with very high HDI were on average showing a progress (i.e. GEP Index above 0). Only about half of the countries with high HDI experienced a progress. Most of the countries in medium and low HDI groups were showing regress from green economy goals.

Table 13 presents the results for each indicator (i.e. no aggregation). Material Footprint and air pollution have the highest mean scores for the Green Growth Index. These indicators show regression in Green Economy Progress Index. This imply that while current performance is very high for these indicators, no progress has been observed in the past years. In contrast, although environmental exports and patents have very low performance, they have shown progress, albeit minimal at an average of 0.1. The indicator on protected areas has performed well for the Green Growth Index with a score of about 75, but it also has shown the largest progress among all indicators with Green Economy Progress Index of 0.6.

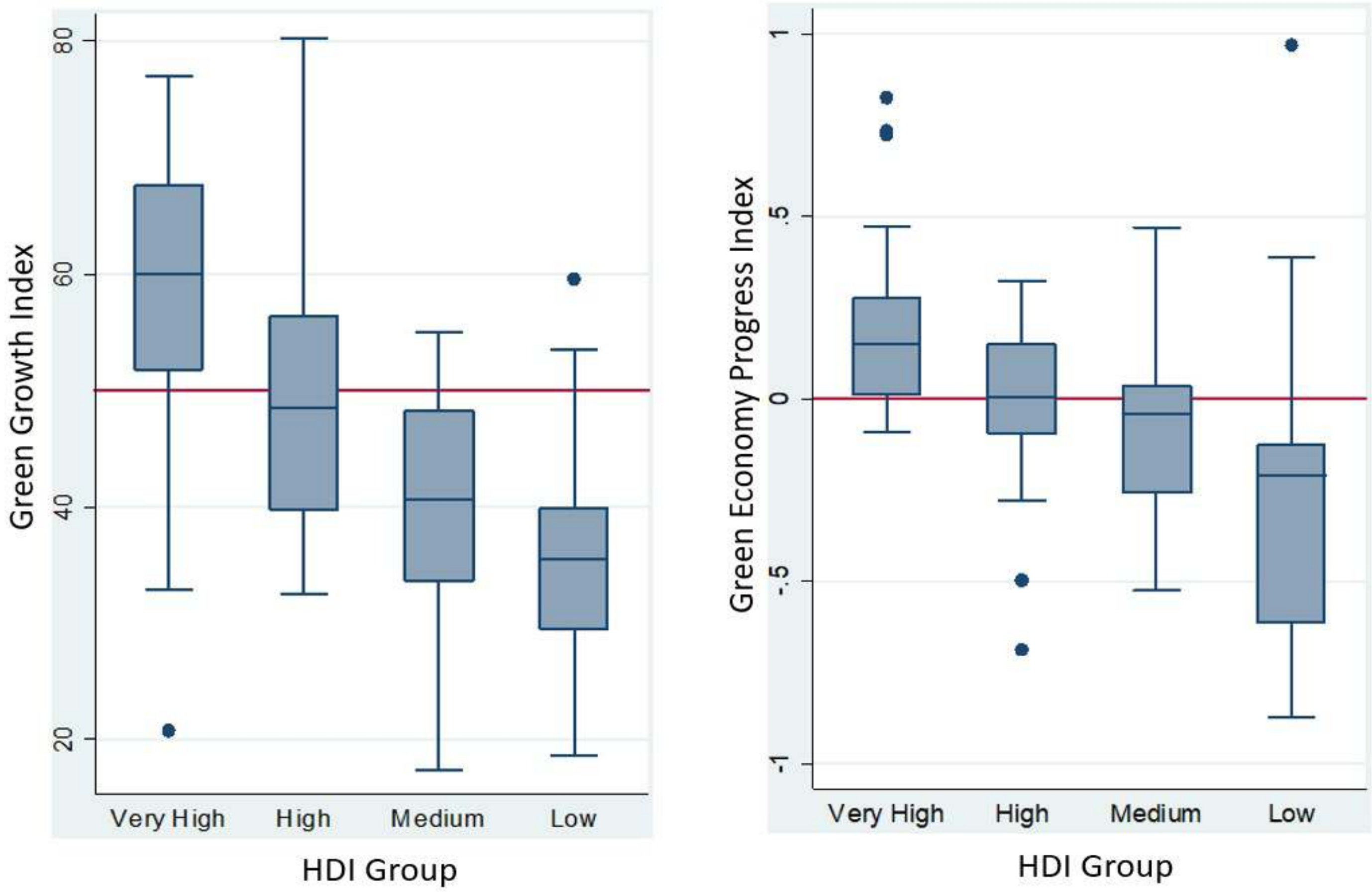


Figure 11. Boxplots of Green Growth Index and Green Economy Progress Index, by HDI group
Source: Authors' calculations
Note: Dots are outliers in the distribution.

Table 13. Comparison of Green Growth and Green Economy Progress Indices, by indicator

Region	Green Growth Index					Green Economy Progress Index				
	Obs	Mean	Std. Dev.	Min	Max	Obs	Mean	Std. Dev.	Min	Max
Renewable energy	107	55.8	32.9	2.4	100	107	0.1	0.48	-0.9	2.0
Material Footprint	107	84.2	19.0	1.0	100	107	-0.6	2.6	-23.1	3.5
Air Pollution	107	82.8	22.4	1.0	100	107	-0.2	0.8	-5.8	2.5
Protected Areas	107	75.2	31.3	2.4	100	97	0.6	1.1	-0.6	7.8
Environmental Exports	105	22.7	19.3	1.0	100	103	0.1	0.2	-0.3	1.1
Environmental Patents	77	25.8	22.7	1.0	100	57	0.1	0.4	-0.3	1.8
Access to Services	82	68.0	27.0	1.0	100	74	0.2	0.4	-0.9	2.0
Income Inequality	104	69.0	18.3	1.0	100	107	-0.3	1.0	-4.4	1.3

Source: Authors' calculations

4.2.2 Correlations

The final section presents the results of a series of statistical analysis that investigates the relationship between the results of the common application for GG and GEP Indices. The analysis focuses on the comparison of scores and ranks generated from the two Index' methodologies.

The country rankings resulting from the common application present few similarities. The correlation of the ranks is 0.42 and statistically significant at the 99% confidence level. Considering the different foci of the two frameworks, the level of association on the order of the country rankings is not trivial. This is due to the similarities in methodological features (e.g. sustainability targets and critical thresholds), as well as the same set of indicators for this common application. Because the correlation is not very high, due mainly to the differences in the GG and GEP Index's frameworks, the ranking order of the countries is not very consistent (e.g. the top ten countries in GG Index are not necessarily the same in GEP Index). Figure 12 presents the scatterplot of the countries' ranking, where the ranks for the GG Index are on x-axis and those for the GEP Index are on y-axis. Overall, there is a positive linear relationship in country ranks between GG and GEP Indices, which means that countries with high green growth performance have also high green economy progress. Figure 13 shows the scatterplot between the scores in GG and GEP Indices. The positive linear relationship among scores confirms the previous results on the ranks. The correlation of scores is 0.39 and statistically significant at the 99% confidence level.[16] Similar to the rank correlation, on average, countries that are currently performing well have also achieved progress over time.

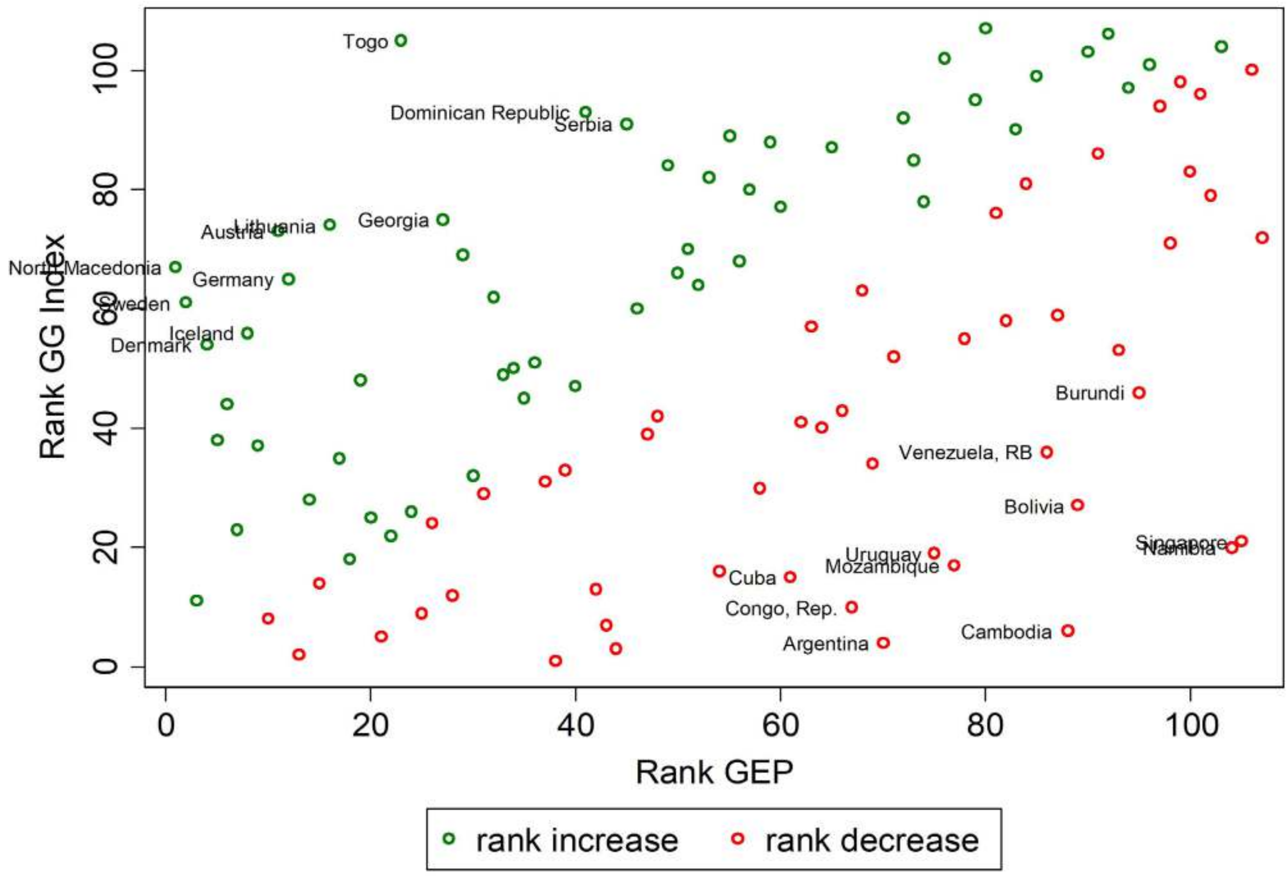


Figure 12. Scatterplot of country ranking for Green Growth Index and Green Economy Progress Index
Source: Authors' calculations

[16] The figure is the plot of the linear regression of the GG Index values on the GEP values for the 107 countries of the common sample. Errors are clustered by HDI group.

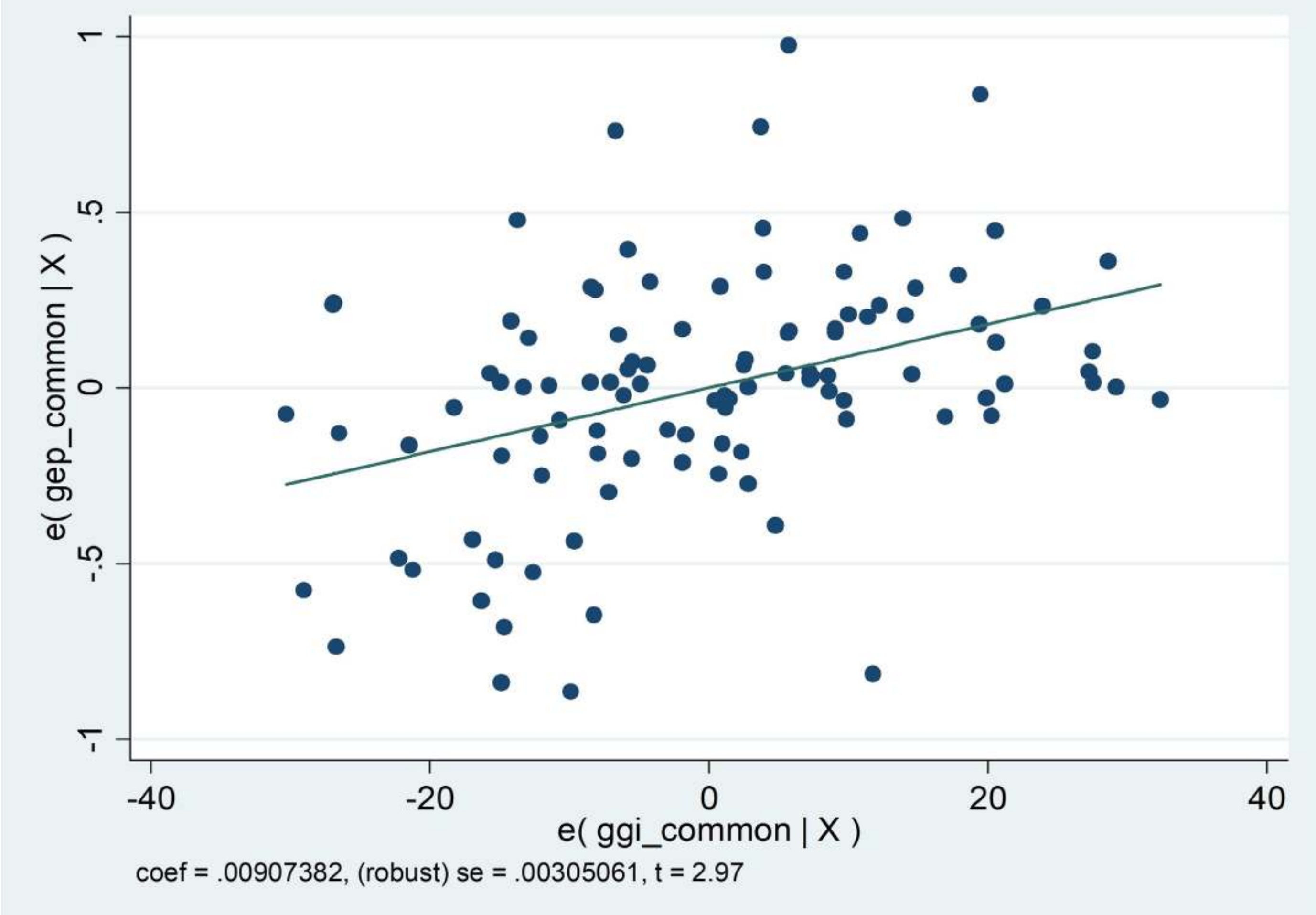


Figure 13. Scatterplot of country scores for Green Growth Index and Green Economy Progress Index
Source: Authors' calculations

However, it is worth noting in Figure 12 that countries whose names are shown on the figure show an interesting pattern. On the one hand, for those countries with green dots – many of them have high HDI (Georgia, Serbia, North Macedonia) and very high HDI (Denmark, Sweden, Austria, Germany, and Iceland), the ranks in green growth performance (GG Index) are higher than the ranks in green economy progress (GEP Index). On the other hand, countries with red dots – some belong to low HDI (Burundi) and medium HDI (Bolivia, Cambodia, Congo Republic, Namibia, Mozambique) groups, have relatively high ranks in green economy progress, but low ranks in green growth performance.

To determine which indicators contributed to the positive relationship in ranks and scores between the GG and GEP Indices, a correlation analysis between the normalized indicators in the GG index and the progress for each indicator in the GEP index was conducted. The results from this analysis are presented in the first row on Table 14. Air pollution, protected areas, and income inequality are the indicators that mainly contributed to the positive relationship in ranks and scores. In particular, air pollution (PM2.5) has a very high positive correlation of 0.74 and statistically significant at 99% level. The remaining indicators show negative relationship between the normalized indicators in the GG index and the progress for each indicator in the GEP index. Except for renewable energy, the negative correlation for the other indicators is quite low at below 20. It can be assumed that these are the indicators that caused digression of few countries from the overall trend, as shown in Figure 12.

Table 14. Correlation among values by each indicator

Types of correlation	Renewable energy	Materia Footprint	Air Pollution	Protected Areas	Environmental Exports	Environmental Patents	Access to Services	Income Inequality
GG normalized scores and GEP progress values	-0.33	-0.12	0.74	0.37	-0.12	-0.07	-0.18	0.15
GG normalized scores and GEP first weights	-0.49	-0.98	-0.98	-0.46	-0.15	-0.69	-0.73	-1.00

Source: Authors' calculations
Note: all the correlation values are significant at the 99% confidence level

Looking at the second row, another interesting point of comparison between the GG and GEP Indices is the relationship between the normalized scores in the GG Index and the first weights in GEP Index. For consistency, most recent data for both normalized scores and first weights (i.e. final period or 2014) were used in the correlation analysis.[17] Results revealed that there is a negative and significant correlation between them, particularly for income inequality, material footprint, air pollution and access to services. This implies that at this step of development of the Index, the GG and GEP Index' methodologies are still quite similar with each other (e.g. benchmarking with targets and thresholds). In terms of policy, the results indicate that the closer the countries' distance to the sustainability targets for green growth (i.e. scores close to 100), the more far off they are from the critical thresholds (i.e. weights equal or below 1).

[17]The first set of weights calculated on the final year of the analysis coincide with the weights that would be used for calculating the GEP relative to decade 2015-2025.

To validate the foregoing results, the number of countries that achieved a score of 100 for the GG Index and a first weight equal or below one in the GEP index were also investigated (Table 15). For material footprint, air pollution, and protected areas, the number of countries meeting the criteria is the same for both Indices. This is attributed to using the same values for the sustainability targets and critical thresholds for these three indicators (Table 11). For the remaining indicators, the critical thresholds for the GEP Index were lower than the sustainability targets for the GG Index (except for income inequality). These thresholds were referred to as aspirational values in the GEP Index, and thus easier to achieve than the GG Index's sustainability targets. The results are thus consistent to the methodologies applied in the two Indices.

Table 15. Countries reaching 100 in the GG Index and with weights equal or below 1 in the GEP Index

Index	Renewable energy	Material Footprint*	Air Pollution*	Protected Areas*	Environ-mental Exports	Environmen-tal Patents	Access to Services	Income Inequality
Green Growth	25	32	12	54	1	0	1	1
Green Economy Progress	100	32	12	54	94	99	89	79

Source: Authors' calculations
Note: *Indicators have the same values for the sustainability target and the critical threshold.

05 CONCLUDING REMARKS

The GG Index by the GGGI and the GEP Index by the PAGE are measurement tools developed for analyzing green growth performance and green economy progress at a global and country level. The frameworks for these two Indices present several diversities and commonalities. The analytical focal points are the main differences: while the GG Index measures countries' green growth performances at present time, the GEP Index measures progress made by countries towards an inclusive green economy over time. This conceptual specificity is the main source of divergence in the other common frameworks, which both GGGI and UNEP developed based on the GGKP's proposed framework on constructing green economy indicators. As part of their frameworks, both Indices considered the link to the indicators and targets relevant to the SDGs.

But the difference in analytical focal points required the development of the GG and GEP Indices to apply important divergent methodologies related to indicator aggregation (including dealing with outliers, weights, normalization, and level of aggregation). Moreover, the difference has an effect on the interpretation of the results and policy implications. Comparisons of results generated from the original frameworks and methods of the two Indices showed some degree of complementarities. To determine how strong are the complementarities between them, common application using the same sets of indicators was conducted for the GG and GEP Indices. In this comparative exercise, the original frameworks and methods of the two Indices were likewise applied. The results, which were analyzed by region and HDI groups, showed interesting complementarities between the Indices. To validate the degree of complementarities, several statistical analyses were conducted (i.e. scatterplots, correlation). Except for few country outliers, the relationship between the Indices revealed positive linear relationship with the following policy implications:

- Countries with high green growth performance have also high green economy progress;
- Air pollution, protected areas, and income inequality mainly contributed to the positive relationship between current performance and progress over time; and
- Countries that are closer to achieving the sustainability targets are more far off from exceeding thresholds of planetary boundaries.

The complementarities revealed in this report suggest that, while each Index is a useful standalone tool for assessing green growth and green economy issues, combining their applications will provide a more dynamic and complete picture on green pathways to development. In particular, the combined applications will be able to identify country outliers from the general trend (i.e. positive relationship between current performance and progress over time) and trace which indicators contribute to their digression from green pathways.

REFERENCES

Acosta, L. A., Maharjan, P., Peyriere, H., Galotto, L., Mamiit, R. J., Ho, C., … Anastasia., O. (2019). Green Growth Index: Concept, Methods and Applications. GGGI Technical report No. 5, Green Growth Performance Measurement (GGPM) Program, Global Green Growth Institute, Seoul.

Acosta, L. A., Mamiit, R. J., Ho, C., Gunderson, I., Anastasia, O., Angawi, M., … Shrestha, C. (2019). Assessment of feedback from regional expert consultations on the Green Growth Index (Phase 2). GGGI Technical report No. 7, Green Growth Performance Measurement (GGPM) Program, Global Green Growth Institute, Seoul.

AfDB. (2014). Transitioning towards Green Growth: A Framework for the African Development Bank. In Report. Retrieved from http://www.greengrowthknowledge.org/resource/transitioning-towards-green-growth-framework-african-development-bank

Allen, C., & Clouth, S. (2012). A guidebook to the Green Economy. New York: United Nations Department of Economic and Social Affairs (UN DESA).

Bass, S., Steele, P., Toulmin, C., Greenfield, O., Hopkins, C., Chung, I., & Neilsen, T. (2016). Pro-poor, Inclusive Green Growth: Experience and a New Agenda. In Global Green Growth Institute. Retrieved from https://pubs.iied.org/pdfs/G04050.pdf

Brauer, M., Freedman, G., Frostad, J., van Donkelaar, A., Martin, R.V., Dentener, F., … Cohen, A. (2016). Ambient Air Pollution Exposure Estimation for the Global Burden of Disease 2013, Environ. Sci. Technol. 50(1), 79-88. https://pubs.acs.org/doi/pdf/10.1021/acs.est.5b03709

Bringezu, S., Schütz, H., Steger, S., & Baudisch, J. (2004). International comparison of resource use and its relation to economic growth: The development of total material requirement, direct material inputs and hidden flows and the structure of TMR. Ecological Economics, 51(1–2), 97–124. https://doi.org/10.1016/j.ecolecon.2004.04.010

ECN. (2013). Resource Efficiency: What does it mean and why is it relevant? Policy brief. ECN Policy Studies, Petten, The Netherlands.

GEC. (2012). Nine Principles of a Green Economy. Retrieved December 10, 2019, from Green Economy Coalition website: https://www.greeneconomycoalition.org/news-analysis/sign-9-principles-green-economy

GGGI. (2017). Accelerating the Transition to a New Model of Growth: GGGI Refreshed Strategic Plan 2015 – 2020. Retrieved from https://www.gggi.org/

GGKP. (2013). Moving towards a Common Approach on Green Growth Indicators. In Green Growth Knowledge Platform Scoping Paper. Retrieved from Global Green Growth Institute (GGGI), Organisation for Economic Co-operation and Development (OECD), United Nations Environment Programme (UNEP), and World Bank website: https://www.greengrowthknowledge.org/node/4620/

Hallegatte, S., Heal, G., Fay, M., & Treguer, D. (2012). From Growth to Green Growth - a Framework. In Policy Research Working Paper 5872, The World Bank. https://doi.org/10.3386/w17841

Jha, S., Sandhu, S. C., & Wachirapunyanont, R. (2018). Inclusive Green Growth Index: A new benchmark for quality of growth. https://doi.org/http://dx.doi.org/10.22617/TCS189570-2

Kasztelan, A. (2017). Green growth, green economy and sustainable development: Terminological and relational discourse. Prague Economic Papers, 26(4), 487–499. https://doi.org/10.18267/j.pep.626

Leadley, P. W., Krug, C. ., Alkemade, R., Pereira, H. M., Sumaila, U. R., Walpole, M., … Mumby, P. J. (2014). Progress towards the aichi biodiversity targets: An assessment of biodiversity trends, policy scenarios and key actions. In Technical Report. Retrieved from http://www.cbd.int/doc/publications/cbd-ts-78-en.pdf

Natural Capital Committee. (2014). Towards a Framework for Defining and Measuring Change in Natural Capital (No. Working Paper No. 1). Retrieved from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/516946/ncc-working-paper-measuring-framework.pdf

OECD. (2011). Towards Green Growth: A Summary for Policymakers. OECD Publishing, Paris, France.

OECD. (2019). Measuring Distance to the SDG Targets 2019: An Assessment of Where OECD Countries Stand. Paris, France.

PAGE. (2017a). The Green Economy Progress Measurement Framework Application: Evaluating National Progress Towards Poverty Eradication and Shared Prosperity within Planetary Boundaries. Geneva, Switzerland: PAGE Secretariat, United Nations Environment Programme.

PAGE. (2017b). The Green Economy Progress Measurement Framework Methodology: Evaluating Progress Towards Poverty Eradication and Shared Prosperity Within Planetary Boundaries. Geneva, Switzerland: PAGE Secretariat, United Nations Environment Programme.

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S., Lambin, E. F., … Foley, J. A. (2009). A safe operating space for humanity. Nature, 461(24), 472–475.

Sachs, J., Schmidt-Traub, G., Kroll, C., Lafortune, G., & Fuller, G. (2019). Sustainable Development Report 2019: Transformations to achieve the Sustainable Development Goals. In Bertelsmann Stiftung and Sustainable Development Solutions Network (SDSN). Retrieved from https://www.sdgindex.org/

Tamanini, J., Bassi, A., Hoffman, C., & Valenciano, J. (2014). The Global Green Economy Index: Measuring National Performance in the Green Economy 4th Edition. Retrieved from https://dualcitizeninc.com/GGEI-Report2014.pdf GGEI

UN ESCAP. (2013). Green growth indicators: A practical approach for Asia and the Pacific. https://doi.org/10.1017/CBO9781107415324.004

UNCTAD. (2011). The Green Economy: Trade and Sustainable Development Implications. Retrieved from https://unctad.org/en/docs/ditcted2011d5_en.pdf

UNEP. (2011). Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication. Retrieved from https://sustainabledevelopment.un.org/content/documents/126GER_synthesis_en.pdf

United Nations. (2019). SDG Indicators Metadata Repository. UNSTATS Sustainable Development Goals. Retrieved December 10, 2019, from Sustainable Development Goals website: https://unstats.un.org/sdgs/metadata/

Vazquez-Brust, D., Smith, A. M., & Sarkis, J. (2014). Managing the transition to critical green growth: The "Green Growth State." Futures, 64, 38–50. https://doi.org/10.1016/j.futures.2014.10.005

WHO. (2005). WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide: Global update 2005. In World Health Organization. https://doi.org/10.1016/0004-6981(88)90109-6

WHO. (2014). WHO guidelines for indoor air quality: household fuel combustion. WHO Press, World Health Organization, Geneva, Switzerland.

WIPO. (2018). WIPO statistics database. World Intellectual Property Organization (WIPO). Last updated: December 2018. https://www3.wipo.int/ipstats/index.htm?tab=patent

GGGI

Follow our activities on
Facebook and Twitter

www. gggi.org