PAGE PARTNERSHIP FOR ACTION ON GREEN ECONOMY

THE GREEN ECONOMY PROGRESS MEASUREMENT FRAMEWORK METHODOLOGY

EVALUATING NATIONAL PROGRESS TOWARDS POVERTY ERADICATION AND SHARED PROSPERITY WITHIN PLANETARY BOUNDARIES

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LIST OF ACRONYMS

APEC	Asia-Pafic Economic Cooperation
GEP	Green Economy Progress
GGGI	Global Green Growth Institute
GGKP	Green Growth Knowledge Platform
HDI	Human Development Index
ILO	International Labour Organization
IWI	Inclusive Wealth Index
OECD	Organisation for Economic Co-operation and Development
PAGE	Partnership for Action on Green Economy
PPP	Purchasing Power Parity
SDGs	Sustainable Development Goals
UN	United Nations
UNDP	United Nations Development Programme
UNIDO	United Nations Industrial Development Organization
WDI	World Development Indicators
WIPO	World Intellectual Property Organization

EXECUTIVE SUMMARY

UN Environment has developed a Green Economy Progress (GEP) Measurement Framework to help countries evaluate their overall progress towards an Inclusive Green Economy and to enable a cross-country comparison of progress. The GEP Measurement Framework complements UN Environment's previously developed green economy indicators framework (UNEP, 2012; UNEP, 2014; and UNEP, 2015), which uses several types of indicators at different stages of a typical policymaking cycle.

The GEP Measurement Framework has four objectives. The first is to support the assessment of progress in achieving a selection of the SDGs within the 2030 Sustainable Development Agenda and establishing direct links with them.[1] The second is to help countries monitor progress against nationally set targets in priority areas and the third is to introduce greater levels of transparency to policymaking and provide policymakers with the tools necessary to set-up policies that support the transition to an Inclusive Green Economy. The fourth and final objective is to measure and compare green economy efforts across countries.

The GEP Measurement Framework is anchored in an Inclusive Green Economy narrative. 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. The GEP Index captures these multi-dimensions of an Inclusive Green Economy. It includes measurements of accumulation of capital – be it natural, low carbon and resource efficient, human, or social[2] – which serves as input for producing goods and services in an environmentally friendly manner. It also attempts to capture the transition of consumption, investment, government spending and trade towards such goods and services. The GEP Measurement Framework also includes measurement of the outcome of enabling policies that are conducive to an Inclusive Green Economy. Progress in improving these outcomes is then analysed against specific planetary boundaries, such as greenhouse gas emissions, water and land use.

In its initial version, the GEP Measurement Framework is composed of a GEP Index and a companion Dashboard of Sustainability indicators. These components can be both analysed individually and combined to allow the ranking of progress by country (GEP+). The first component, the GEP Index, measures the progress made in improving the well-being of current generations in relation to economic opportunities, social inclusiveness and environmental protection. It is composed of 13 indicators that capture critical issues faced in achieving an Inclusive Green Economy transition, such as material footprint and inequality. The GEP Index focuses on the progress achieved by countries with respect to a target set for each individual indicator. Construction of the GEP Index utilizes a weighting system that allows for the assessment of how far off a country is from the global threshold on a specific component of an Inclusive Green Economy (an indicator) and an evaluation of the relative importance of one component (an indicator) with respect to the others from the country's perspective. The Dashboard of Sustainability includes six indicators that track the sustainability of any progress that has been achieved as measured by the GEP Index. Its role is to monitor the long-term sustainability of the factors underpinning humanity's current and future well-being.

The GEP Measurement Framework, in its current version, proposes a method for measuring progress

that monitors changes in key variables, taking into account global thresholds that should not be surpassed and utilizing achievable targets selected to help countries to move in the right direction through policy intervention. These components are critical to obtaining a useful measure of progress, making the measurement framework a valid instrument for not only practitioners, but also for the wider community of researchers and academics working in the field.

There are important challenges associated with this line of work and it should be noted that there is much progress still to be made. Conceptual challenges remain with respect to the integration of the GEP Measurement Framework and the Inclusive Green Economy narrative as a result of the latter's complexity and the different implicit and explicit causal relations that exist. In addition, there are empirical challenges related to the availability of indicators. While the focus on progress is a significant added value of this work, it also imposes considerable constraints on the potential indicators that can be used. From a policy perspective, an additional challenge lies in how to make use of available national level indicators, which tend to better capture local realities. The methodology offered by the GEP measurement framework is flexible enough to overcome these practical challenges. A separate publication presents an application of the methodology at the global level to Beta test the methodology and to see the different tradeoffs and challenges of the methodology to improve its design, and more importantly, to enrich the green economy policy making analysis.[3]

There are at least two ways to expand on the GEP Measurement Framework for policymaking in the future. First, the methods used in the framework are flexible when it comes to selecting indicators, thereby making inter-country comparison possible on any particular aspect of an Inclusive Green Economy as long as the underlying data is available. Important indicators that are currently unavailable (such as those that adequately reflect biodiversity and green jobs) may be incorporated into the framework whenever they become accessible, thus expanding the scope of measurement. Second, the framework can build on UN Environment's other related work on indicators (namely ***Measuring Progress towards an Inclusive Green Economy - 2012, Guidance Manual for Green Economy Indicators - 2014, and Indicators for Green Economy Policymaking Synthesis Report of Studies in Ghana, Mauritius and Uruguay – 2015***) by adjusting the choice of indicators to specific country needs and priorities. This extension would make the framework more useful in facilitating policymaking in a specific country. The GEP Measurement Framework is particularly useful for the monitoring of SDGs at the country and global level, given its strong linkages with many of the SGDs. The current Beta test application of the methodology has 14 direct links to 10 of the 17 SDGs.[4] This will help not only in the monitoring process, but also in the integration and articulation of policies by enhancing the linkages between IGE policies to the overall objectives of sustainable development.

1. INTRODUCTION

In June 2012, the United Nations Conference on Sustainable Development ("Rio+20") endorsed a series of agreements, two of which stand out with the ability to alter the way countries approach sustainability. First, governments agreed to negotiate a set of Sustainable Development Goals (SDGs) that would be universal, aspirational and transformational. Second, they agreed that a green economy approach could be a tool for achieving this sustainable development by contributing to "(…) ***eradicating poverty as well as sustained economic growth, enhancing social inclusion, improving human welfare and creating opportunities for employment and decent work for all, while maintaining the healthy functioning of the Earth's ecosystems***." (Art. 56, "The Future We Want").[5] In this context, Rio+20 also called on the United Nations to provide technical assistance to those countries wishing to pursue green economy policies, including through the creation of measures and metrics that would help track progress of efforts to green economies and achieve sustainable development. In September 2015, 193 UN Member States agreed on a new Sustainable Development Agenda to end poverty by 2030 and pursue a sustainable future, supported by a list of 17 SDGs and 169 related targets.

As the global leader of the Green Economy Initiative, UN Environment is well positioned to catalyze the development of green economy indicators with a view of supporting the implementation of the green economy concept at the country level. At the global level, UN Environment conducted a study in 2012 on how to use indicators to develop and track green economy policies (UNEP, 2012). In 2013, UN Environment partnered with the OECD, the World Bank, and the Global Green Growth Institute (GGGI) via the Green Growth Knowledge Platform (GGKP), to develop a common green growth indicators framework (GGKP, 2013).

At the country level, UN Environment, under the Partnership for Action on Green Economy (PAGE), developed a framework that combines four types of indicators into an integrated policymaking process (UNEP, 2014). Each type is designed to assist at specific stages of green economy policymaking.

First, ***indicators for issue identification*** help identify and prioritize problems to be resolved through a green economy approach. Second, ***indicators for policy formulation*** help design solutions by defining targets and measuring different policy interventions. Third, ***indicators for policy assessment*** provide critical inputs for estimating the cross-sectoral impact of policy implementation and for evaluating the effectiveness of each policy option. Finally, ***indicators for policy monitoring and evaluation*** assess the real impact of implemented policies in the medium to long run. This framework was tested in Ghana, Mauritius, and Uruguay, where green economy indicators were identified as powerful instruments to engage stakeholders in shaping the policymaking process (UNEP, 2015). However, the country studies also identified challenges in terms of availability and quality of data.[6]

In order to bridge measurement initiatives at the global level with the indicator work carried out at the country level, UN Environment has developed a new GEP Measurement Framework that will facilitate cross-country comparison of national efforts to transition to greener and more inclusive economies.[7]

2. PROMOTING THE TRANSITION TO AN INCLUSIVE GREEN ECONOMY[8]

An Inclusive Green Economy is a pathway for delivering sustainable development and a response to three sets of global challenges, namely: (a) persistent poverty; (b) overstepped planetary boundaries; and (c) inequitable sharing of growing prosperity. How could this tool be promoted to address these challenges and ensure a sustainable future for all people on the planet?

The Inclusive Green Economy contributes to the overarching goal of poverty eradication and shared prosperity in an intergenerational context by safeguarding planetary boundaries, some of which, e.g. climate, freshwater, ocean and land, are mirrored by the SDGs. Planetary boundaries should serve as drivers for innovative solutions that respect ecological thresholds while improving the livelihoods of communities around the world. In Africa, for example, where more than 600 million people lack access to affordable and reliable energy, off-grid renewable energy technologies are generating new opportunities in health care, education and the wider economy, and contributing to reducing carbon emissions.

UN Environment's Inclusive Green Economy Initiative puts a strong emphasis on the role of investment and enabling policies to meet sustainable development targets. In the evolving narrative of the Inclusive Green Economy such solutions and outcomes are generated through the transformation of economic growth, which is traditionally determined by the market value of the goods and services produced with little regard to how goods and services are produced and/or consumed. An Inclusive Green Economy emphasizes the accumulation of a new generation of assets (Rockström et al, 2009) that are necessary to produce goods and services in an environmentally friendly manner.[9] However, research on a case-by-case basis is required to identify the complementarities and trade-offs that exist between these assets for producing such goods and services. Moreover, such goods and services should be produced through decent work and should contribute to social inclusion. At the same time, to induce the transformation of production, an Inclusive Green Economy also promotes the switch of consumption, investments, public spending and trade towards goods and services produced with the new generation of assets.

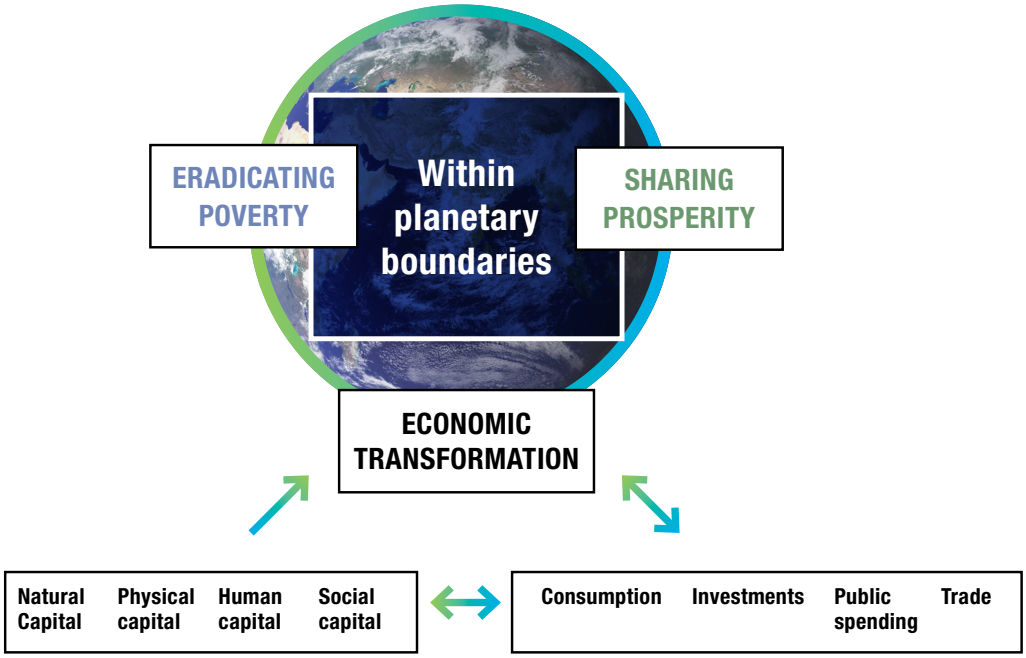
Any changes in aggregate demand and supply will ultimately be constrained by global ecological thresholds. However, in some cases, these thresholds have already been crossed, as suggested by the theory of planetary boundaries put forth by Rockström et al. (2009). Governments have traditionally regulated economic activities to limit their environmental impact. Examples include emission standards for new vehicles and crop rotation legislation to safeguard soil quality. Under an Inclusive Green Economy approach, planetary boundaries should not only be adhered to in a reactive manner but should also be seized as opportunities for the introduction of innovative measures that contribute in particular to "sustained, inclusive and sustainable growth, full and productive employment and decent work for all" (SDG 8).

These systemic changes do not typically take place automatically. Amazonian forests sequester carbon and host biodiversity for the benefit of humanity at large. Individuals, businesses, and even governments of the Amazon region might not consider it fair for them alone to invest in Amazonian forest conservation. Owners of properties might not be interested in investing in green buildings if the tenants are the primary beneficiaries from reduced utility bills. Consumers

might not want to buy energy-saving appliances if the initial costs are significantly higher than regular appliances. Businesses might find that investing in the production of durable products may not work to their advantage.

This is why policies are essential for incentivizing actions. Particular emphasis should be placed on policies that can mobilize finance to build the new generation of all forms of capital and/or reshape consumption patterns, investment, public spending and trade. Examples include: (a) fiscal policy (e.g. reform of fossil fuels can encourage energy efficiency in both consumption and production); (b) industrial policy (e.g. government spending on research & development (R&D) for renewable energy technologies); (c) sustainable public procurement; (d) labour training; (e) social safety nets; and (f) trade liberalization for environmental goods and services. Other policies, such as rules, regulations and standards remain important and should complement green economy policy instruments that focus more directly on mobilizing finance for the transition towards an Inclusive Green Economy. Figure 1 illustrates how the three sets of challenges that an Inclusive Green Economy aims to address are interconnected.

Figure 1: *Sets of challenges that an Inclusive Green Economy aims to answer*



UN Environment has developed the ***Green Economy Progress (GEP) measurement framework***, as an integrated policy instrument that both assesses country efforts towards achieving targets set within planetary boundaries and allows cross-country comparison of progress[10] towards achieving an Inclusive Green Economy.

2.1 OBJECTIVES OF THE GEP MEASUREMENT FRAMEWORK

The GEP Measurement Framework is intended to achieve four objectives:

› **The first objective is to contribute to the monitoring of progress in implementing the SDGs through establishing direct links with selected SDGs.**[11] This will help monitor progress for specific SDG targets and support the measurement and implementation of the 2030 Sustainable Development Agenda.

› **The second objective is to assess progress towards national goals in priority areas**. The framework allows countries to include national indicators and targets in their "customized-GEP" measurement framework to track progress in specific areas.[12]

› **Third, the GEP Measurement Framework will bring transparency and accountability to policymaking, draw public attention to sustainable development challenges, and highlight the importance of achieving progress in an integrated manner**. If accepted as a basis for comparison of green economy progress between nations, the GEP Measurement Framework may also serve to inspire policymakers and galvanize civil society to push governments toward the pursuit of ambitious Inclusive Green Economy agendas. It may also help policymakers in identifying policy gaps where more resources are required to increase the speed and scope of greening their economies and making them more inclusive.

› **Finally, the GEP Measurement Framework is able to compare the efforts made by countries in achieving the transition towards an Inclusive Green Economy**. The GEP Measurement Framework helps countries assess where they stand in key Integrated Green Economy areas while revealing the challenges that arise from becoming less reliant on carbon fuels and the opportunities of becoming resource efficient and socially inclusive. The GEP Measurement Framework serves as a signal to countries to change their development path by designing or reforming national policies to promote the transition to an Inclusive Green Economy. By tracking their green economy progress over time, countries can evaluate how fast they are able to achieve specific targets and measure the speed of their transition towards an Inclusive Green Economy.

2.2 PROGRESS ON ACHIEVING AN INCLUSIVE GREEN ECONOMY

There are two important conditions for progress: (a) progress should aim to generate multidimensional impacts (i.e. it should reflect the result of an integrated impact on the economic, social and environmental dimensions of sustainable development); and (b) progress should be evaluated from a medium and long-term perspective. These conditions are discussed in detail below.

An Inclusive Green Economy could, among other things, be interpreted as a means of decoupling economic growth from resource use and environmental impacts (e.g. reducing material and environmental footprint). To achieve decoupling, key factors and policies must be established, including: (a) private and public investment aimed at greening the economy; (b) fiscal policies (e.g. ecological tax reform and phasing out harmful subsidies); (c) enhanced market access for low carbon technologies and sustainable technologies in general; (d) development of green industrial policies; (e) generation of green jobs; and (f) promotion of social inclusion and use of trade opportunities from new markets and technological innovation. Progress can only be considered to have been achieved if these improvements in current human well-being are sustainable, therefore requiring that the future development path stays within planetary boundaries.

2.2.1 Progress as measured by the GEP Measurement Framework

The GEP Measurement Framework uses a set of green economy indicators to measure progress against set targets. Any green economy progress made is measured for each individual indicator, and is aggregated in a composite index across dimensions where there is a valid[13] policy substitutability.

Green economy progress on each individual indicator is measured as the ratio between the actual change observed and the desired change with respect to a target for that indicator. Green economy progress in the multidimensional case is measured by the aggregation of progress across indicators for each country into a composite index. This provides an overall picture of progress achieved by each country and allows cross-country comparison of efforts for peer groups of countries for a same set of indicators. For a meaningful comparison across indicators within a country and across countries, a weighting system that allows for a combination of progress across different indicators is required: this is in essence the GEP Index, which will be discussed in the next section.

3. THEORETICAL FRAMEWORK[14]

Two preliminary considerations must be flagged before presenting the theoretical framework. First, it is not possible to quantify everything that should ideally be measured. Second, not all measurable variables can be reasonably aggregated into a single number. This implies that indices will only provide a partial estimate of the performance that is being evaluated. Complementing a single number with a dashboard of indicators might be most useful. A comprehensive index (e.g. the Human Development Index) may help to depict a synthetic picture of how certain aspects of interest are evolving as a whole. In contrast, a dashboard of indicators not only provides complementary information to complete the picture given by the index, but may also help better understand the nature of the changes in the indicators of the index, both across time and between countries.

As described in Section 2, the theoretical framework looks at two types of progress: green economy progress in single indicators and multidimensional green economy progress through the GEP Index. Progress on a single indicator measures country achievements for that particular indicator and informs the country on its performance in one particular area of development. The GEP Index measures progress in achieving the transition towards an Inclusive Green Economy by aggregating individual progress across dimensions and weighting the results to make the index comparable between and within countries. The value of the GEP Index is that it:

1. Identifies key dimensions to be associated with an Inclusive Green Economy, each of which may be approximated by one or several variables (see previous section);

2. Focuses on the progress made, i.e. the changes rather than the levels; and

3. Measures the progress made relative to some standards, i.e. targets and thresholds. Targets refer to desired changes, whereas thresholds define some critical levels.

The GEP Index[15] refers to the evolution of the green components in the economic process rather than to sustainable growth or human development as measured by the Human Development Index. This emphasis involves some radical choices, in particular by putting GDP aside as a reference variable for the evaluation and substituting it with green components, such as green trade or green innovation.[16] Two reasons explain why this approach relies on quantitative measures rather than on market values as the key inputs for the GEP Index. First, using market prices to value the considered elements is not adequate because market prices reflect demand and supply forces, which are clearly dominated by developed and large emerging countries. Second, most green economy-related variables refer to goods and services for which there are no well-established markets.

3.1 PROGRESS IN THE SINGLE INDICATOR CASE

3.1.1 The setting[17]

Suppose, for the time being, that progress is evaluated for only one country based on a single indicator. Focusing on progress results in the definition of achievements and targets in terms of changes. Note that the effect on the measure of progress in the case of "goods" and "bads" will be different: increasing the amount of a "good" will increase the measure of progress, whereas increasing the amount of a "bad" will decrease it.

Let y^1, y^0 stand for the actual and the initial reference values of the variable that approximates the considered dimension, and let $dy = y^1 - y^0$. Progress (p) with respect to the initial reference value is defined as follows:

$$p_{goods}(y^1, y^0) = \frac{dy}{y^0},\ p_{bads}(y^1, y^0) = \frac{d(-y)}{y^0}$$

The progress in this dimension is simply the corresponding growth or reduction rate of the variable.

Let now y^* denote the desired value of the variable, and call $dy^* = y^* - y^0$. Then, the target will be given by:

$$s_{goods}(y^*, y^0) = \frac{dy^*}{y^0},\ s_{bads}(y^*, y^0) = \frac{d(-y^*)}{y^0}$$

Therefore, applying the evaluation formula in this special case gives the following expression of progress:

$$Progress = \begin{cases} \frac{p_{goods}(y^1, y^0)}{s_{goods}(y^*, y^0)} = \frac{dy}{dy^*} = \frac{y^1 - y^0}{y^* - y^0} \\ \frac{p_{bads}(y^1, y^0)}{s_{bads}(y^*, y^0)} = \frac{d(-y)}{d(-y^*)} = \frac{y^0 - y^1}{y^0 - y^*} \end{cases}$$

That is, progress in the single indicator case corresponds to the ratio of the actual and desired increments (for the case of "goods") or reductions (for the case of "bads"). The progress measure for "bads" is obtained by reversing that of the "goods", both in the numerator and in the denominator.

The progress function is increasing and linear in y^1 for the case of "goods", and decreasing and linear in y^1 for the case of "bads". The derivative of the progress function with respect to y^0 is positive when $y^1 > y^*$ and negative otherwise. Trivially, the function is decreasing in y^*. The index is above or below one depending on whether actual progress is above or below the target. It is negative in the case of regress.

Remark: *When there are several countries, international comparisons for each indicator can be performed directly by confronting their rates of achievement or the progress made on each indicator.*

3.1.2 Targets and thresholds

Progress is synonymous with moving in the "right" direction; therefore, any observed change of an indicator will be assessed against a target and a threshold. Note that in this formulation, the threshold, denoted by t, plays no apparent role so that progress for any indicator is simply the ratio between actual and desired change. The choice of y^* is, therefore, an important decision of the evaluation protocol. There is a natural way of combining these two aspects, the choice of the target and making the threshold play a role.

It is the following in the case of "goods":

$$y^* = \max\{t, \lambda y^0\}, \lambda > 1$$

and the following in the case of "bads":

$$y^* = \min\{t, \beta y^0\}, \beta < 1$$

This formulation indicates that countries must have a desirable change or target y^* set to be on the "right" side of the threshold (or, at a minimum, a target of reaching the threshold). For "goods", countries should never be below the threshold in the final period, whereas for "bads", they should never be above the threshold in the final period. Even if countries are already on the "right" side of the threshold, they should still be making progress and λ and β need to be determined (see Section 4.5 below). This formulation provides a method of doing so in which the threshold is a relevant element.
The rationale of this method of defining y^* is the following. In the case of "goods", any sensible target can be expressed as $y^* = \lambda y^0$, with $\lambda > 1$ (i.e. an increase in the initial value of the variable). This is admissible as long as $\lambda y^0 > t$, i.e. when a country is above the threshold. Otherwise, one should require $y^* = t$ as t is the minimum admissible value. In other words, for "goods", if a country is initially below the threshold and multiplying this value by more than one still results in a value that is lower than the value of the threshold, then the target for this country should be to at least reach the threshold. In the case of "bads", the reasoning is symmetric. A target takes the form $y^* = \beta y^0$, with $\beta < 1$ (i.e. a decrease in the initial value of the variable). This is admissible provided $\beta y^0 < t$, , i.e., a country is below the threshold. Otherwise, one should require $y^* = t$, as t is the maximum admissible value.

Once the target is formulated this way, the following expression is obtained:

$$Progress = \begin{cases} \frac{dy}{dy^*} = \frac{y^1 - y^0}{max\{t, \lambda y^0\} - y^0}, & \lambda > 1 \\ \frac{d(-y)}{d(-y^*)} = \frac{y^0 - y^1}{y^0 - min\{t, \beta y^0\}}, & \beta < 1 \end{cases}$$

The function of progress is always increasing and linear in y^1 in the case of "goods" and decreasing and linear in y^1 in the case of "bads". The derivative of progress with respect to y^0 depends on whether $y^* = t$ or $y^* = \lambda y^0$, but in either case it is negative in the case of "goods", and positive in the case of "bads", whenever $y^* = \lambda y^0$, (i.e. lower initial values yield a higher value of "Progress" for each given progress in the case of "goods"). When $y^* = t$, the derivative of "Progress" with respect to y^0 is positive if $y^1 > t$, zero if $y^1 = t$, and negative otherwise. In other words, crossing the threshold in the right direction involves a premium. Trivially, "Progress" is decreasing in y^* for the case of "goods", and increasing for the case of "bads".

The index takes on a value above or below one, depending on whether actual progress is above or below the target. It is positive in case of progress and negative in the case of regress. When GEP is equal to one this means the country is equivalent to a position in which it met its target, when it is greater than one this means the country is equivalent to a position where it exceeded its targets, so on and so forth. If a single indicator is considered, any progress made can be compared across countries in this indicator by simply comparing the progress functions, keeping in mind that different countries may have different targets. This means relative realizations are always compared with a common element given by the threshold.

3.2 THE GEP INDEX (PROGRESS IN THE MULTIDIMENSIONAL CASE)

For a composite index to be well connected to the policymaking process, it is preferable to have a normative weighting system that helps to understand and guide policy. The normative weighting system must not only recognize that all indicators are potentially of equal importance but also take into account the local and global contexts. The requirement for policy relevance both locally and globally adds complexity to the weights but increases the usefulness of the index for setting policy priorities. The complexity comes from the combination of two competing forces: the need for flexibility of weights in order for them to be different for each country depending on local characteristics and the need for comparisons to be possible along the different dimensions of the data across indicators and across countries (for each indicator across countries, across indicators within a country and the combined comparison). The GEP Index resolves this complexity with a weighting system, which allows progress to be analyzed for each particular indicator across countries, across indicators within a country, as well as overall progress across countries.

Let now:

$$p_{goods}(.) = \frac{dy_j}{y_j^0} = \frac{y_j^1 - y_j^0}{y_j^0}, \qquad p_{bads}(.) = \frac{d(-y_j)}{y_j^0} = \frac{y_j^0 - y_j^1}{y_j^0}$$

where sub-index j refers to a particular indicator, $j \in J$, where $J = G \cup B$ is the set of indicators, consisting of "goods", G, and "bads", B (in the understanding that $G \cap B = \emptyset$).

The weighting methodology to construct the GEP Index is performed in two steps. A first weighting is applied to Progress ($\frac{dy_j}{dy_j^*}$ in the case of "goods" and $\frac{d(-y_j)}{d(-y_j^*)}$ in the case of "bads") to give greater weight to the progress of those countries that are on the "wrong" side of the threshold (below the threshold for goods and above the threshold for "bads"). Consequently, for each indicator, the corresponding weight $\hat{\pi}_j$ is set as the ratio between the initial level of the variables, y_j^0, and threshold t_j:

$$\hat{\pi}_j = \begin{cases} \frac{t_j}{y_j^0}, & if\ j \in G \\ \frac{y_j^0}{t_j}, & if\ j \in B \end{cases}$$

This formulation gives more weight to progress on those indicators in which countries are starting at an initially disadvantaged position with respect to the threshold, but that are making efforts to overcome such a situation.[18] It also provides an initial idea to countries on where to set priorities (the weight is higher the more the country is in a disadvantaged initial position vis-à-vis the relevant threshold), and can be interpreted as an incentive to improve in those indicators in which a country is relatively worse off (i.e. further away from the threshold).

Applying the former model in the case of different weights for different indicators, the following expression for the (not yet normalized) GEP Index is obtained:

$$GEP = \sum_{j \in G} \hat{\pi}_j \frac{dy_j}{dy_j^*} + \sum_{j \in B} \hat{\pi}_j \frac{d(-y_j)}{d(-y_j^*)}$$

The second step is to normalize (or re-weigh) the $\hat{\pi}_j$ to obtain the weights, π_j, which take into consideration the relevance progress in one indicator vis-à-vis the others. This reweighting will indicate the relative importance of one indicator compared to the others and enables aggregation of indicators within a country as well as comparison of

results across countries and across indicators within a country[19]. Let π_j denote the weight attached to indicator j in the aggregate composite GEP Index, with $\sum_{j\in J}\pi_j = 1$.

Normalized weights are then defined as follows:

$$\pi_j = \frac{\widehat{\pi_j}}{\sum_{j\in J}\widehat{\pi_j}}$$

Finally, the following expression for the GEP Index is obtained:

$$GEP = \sum_{j\in G}\pi_j \frac{dy_j}{dy_j^*} + \sum_{j\in B}\pi_j \frac{d(-y_j)}{d(-y_j^*)} \quad [2']$$

which is equivalent to the expression (after substituting the expression for the normalized weights):

$$GEP = \frac{1}{\sum_{j\in G}\frac{t_j}{y_j^0}+\sum_{j\in B}\frac{y_j^0}{t_j}} \times \left[\sum_{j\in G}\frac{t_j}{y_j^0}\frac{dy_j}{dy_j^*} + \sum_{j\in B}\frac{y_j^0}{t_j}\frac{d(-y_j)}{d(-y_j^*)}\right]$$

The double weighting system allows the GEP Index to both assess how far off a country is from the threshold and to evaluate the relative importance of one area (indicator) with respect to the others from the country's perspective. This is a real advantage of the GEP methodology, because it informs national and global action. As time passes and the country's situation evolves, weights in the GEP Measurement Framework will adjust to reflect the new set of priorities. This feature makes the GEP Index (relative to indexes with fixed/common weighting for all countries) a well-suited approach for policy design and monitoring.

Finally, to assess GEP within planetary boundaries, the progress achieved in the GEP Index indicators are compared to the progress made in the indicators of the Dashboard of Sustainability with the goal of highlighting whether planetary boundaries have been overstepped or not. It should be noted that the thresholds of indicators in the dashboard and of some indicators in the GEP Index are determined on the basis of scientific literature, while other thresholds in the GEP Index are empirically determined.

3.3 THE NECESSITY OF A DASHBOARD

It is important to remember that the GEP Index is not intended to be a "sustainable development index", nor an index of "progress" adjusted for sustainability.Assessing sustainability[20] is an exercise that involves the future and is therefore, primarily and unavoidably, a forecasting exercise. A correct and complete assessment of sustainability would require: (a) a correctly specified dynamic stochastic model of the economy and the environment; (b) a correct assessment of present and future preferences for the inhabitants of all countries; (c) a procedure to rank social states within generations; (d) a correct assessment of the degree of substitutability of the different forms of human, social, economic and environmental capital in generating well-being; and (e) a determination of how stringent sustainability tests should be (e.g. sustainability as "future welfare above current welfare" vs. "sustainability as non-decreasing welfare"). With this objective in mind, and under some regularity conditions, one can deem the current socioeconomic path as sustainable if and only if $dV(t) \geq 0$, where:[21]

$$dV(t) := \sum_k p_k \cdot ds_k(t)$$

and the (p_k) are the normatively determined "shadow prices" associated with human, social, economic and environmental capital stocks (s_k).

This measurement exercise would be demanding in practice and questions remain as to whether it would be possible to produce the "correct" sustainability assessment and shadow price system. Additionally, it is highly unlikely that this exercise would be widely accepted as a guide for policy – a problem that is at the core of how to take into account not just the well-being, but also the preferences of future individuals yet to be born.

One way to proceed in light of these challenges is to remain agnostic about prices and keep track of the changes in the stocks, ds_k, and present those changes in a dashboard for each country. This more modest approach is compatible with: (a) an outright acceptance of the intrinsically limited substitutability between the different forms of capital under consideration or, even if it wasn't limited; (b) the extraordinary difficulty, both ethical and technical, in identifying the proper "trade-offs" between forms of capital, as discussed above.

Notwithstanding the fact that those prices are hard to pin down, we must do what we can to assess the importance of the magnitude of the changes that are taking place with these stocks. Thus, one could present relevant thresholds that (according to the relevant scientific literature) are desirable/not desirable to cross and, in addition, targets that will serve to measure the extent to which progress is being made towards meeting certain social, economic or environmental goals. This is the objective of the dashboard, in combination with the GEP Index.

Can we dispense with the index-dashboard dichotomy by simply adding the dashboard variables into the index? We do not believe that this approach is appropriate. To see this, imagine that we have an index of 'sustainability adjusted well-being' that acts like the GEP in regards to the variables that matter for present well-being but that penalizes the growth in variables that threaten the sustainability of that well-being. Any such index may end up classifying countries having, say, low life expectancy and low greenhouse gas emissions and a high value for both in a similar way, while their positions clearly need to be differentiated.[22] This follows as long as we adopt the principle that "we consider it our moral duty not to impose on future generations any form of sacrifice that we do not accept for ourselves".[23]

3.4 AGGREGATING THE INFORMATION FROM THE DASHBOARD AND THE GEP INDEX, CREATING THE GEP+ RANKING

Let the convention be that the variables in the GEP Index contribute, in a comprehensive way, towards the measurement of the welfare or development of the present generation, and carry some limited information on its sustainability. Variables that are related to the sustainability of development are placed in the dashboard. Just as progress was calculated for each indicator ***y*** in the GEP Index, it is calculated for each indicator ***K*** in the dashboard as $\frac{dK_j}{dK_j^*}$, for $j = 1, \dots, J$.

However, for the dashboard indicators it is critical to understand not only progress but also how this progress relates to the sustainability thresholds. This gives specific information about the importance of this progress. For example, if two countries experienced similar progress but one country was already on a sustainable path while another country was not sustainable (above the sustainability threshold), progress for the second country should be considered relatively more important for the overall progress of this country, and the planet, towards IGE. To capture both aspects, we multiply progress on each dashboard indicator by a weight relating the initial condition to the threshold, $\hat{\pi}_j$, (explained previously in section 3.2). This weighting requires an additional modification to the GEP Index in order to allow for comparability between the measures of progress of the GEP Index and the dashboard indicators (now multiplied by the weight). Therefore, in order to facilitate the comparison needed for the construction of the GEP+ ranking, we must multiply the GEP Index by the average of the weights, $\hat{\pi}_j$, of its indicators. These modifications allow for a comparable ***achievement profile*** of each country in the sample.

For a given country, "x" is an achievement profile vector of dimension (*J*+1), which is given by the GEP Index multiplied by the average of $\hat{\pi}_j$ across its indicators and a set of weighted progress measures of the *J* dashboard $\langle \frac{dK_1}{dK_1^*}\hat{\pi}_1, \dots, \frac{dK_J}{dK_J^*}\hat{\pi}_J \rangle$.

Therefore

$$\mathrm{x} = \left(GEP * average\hat{\pi}_j{}^{x}, \langle \frac{dK_1^x}{dK_1^{x*}}\hat{\pi}_1, \dots, \frac{dK_J^x}{dK_J^{x*}}\hat{\pi}_J \rangle \right).$$

Although, for the reasons explained above, the GEP Index should not be combined with the Dashboard of Sustainability in a composite measure of sustainable development, the information from both instruments can nonetheless inform which countries are in a comparably more favorable position than others.

The GEP+ is a final ranking by comparing progress on the indicators in the dashboard with any green economy progress made, as measured by the GEP index[24]. This methodology allows us to rank all index-dashboard profiles but not to combine the index and dashboard information into a synthetic index . When comparing progress based on the GEP Index and the dashboard, countries are ranked according to their least-performing type of progress based on the principle of ***Priority to the Worst Achievement.*** This methodology sends the policy message that a country that is only making progress on a few aspects of an Inclusive Green Economy will not necessarily be doing better than one that is moving forward in all areas. Ranking countries based on the area in which they are making the least progress gives the policy incentive to countries to implement a more balanced and integrated policy approach that is aimed at moving forward across the broad spectrum of an Inclusive Green Economy. This methodology serves a double purpose for countries undertaking Inclusive Green Economy action: it allows them to learn about their relative green economy performance while also informing them on how their least-performing areas of progress compare with the achievements of other countries.[25]

4. FINAL CONSIDERATIONS

The Green Economy Progress measurement framework highlights certain critical aspects of the development challenges that policymakers must address, in an integrated manner, to ensure societies are able to transition towards an Inclusive Green Economy. These challenges include, among others, controlling an increasing material footprint, rising emissions and increased freshwater withdrawal, while at the same time ensuring that further development is not compromised and that economic opportunities are created, ecosystem services are preserved and social inclusiveness is promoted. The GEP Measurement Framework addresses these challenges by providing the advantage of having a double lens through which one can examine progress towards an Inclusive Green Economy.

The Green Economy Progress Measurement Framework, in its current version, proposes a method for measuring progress that monitors changes in key variables, taking into account global thresholds that should not be surpassed and utilizing achievable targets selected to help countries on moving in the right direction through policy intervention. These components are critical to obtaining a useful measure of progress, making the measurement framework a valid instrument for not only practitioners, but also the wider community of researchers and academics working in the field.

There are important challenges associated with this line of work and it should be noted that there is still much progress to be made. Conceptual challenges remain with respect to the integration of the GEP Measurement Framework and the Inclusive Green Economy narrative, because of the latter's complexity and the different implicit and explicit causal relationships that exist. In addition, there are empirical challenges related to the availability of indicators. In fact, one important limitation of the GEP Measurement Framework is the lack of data for a large group of countries and for a long period of time with which to measure progress. While the focus on progress is a significant added value of this work, it also imposes considerable constraints on the potential indicators that can be used. For example, some available indicators are only approximate proxies of what we are attempting to measure, while other indicators are of better quality, but are limited in time and country coverage. From a policy perspective, an additional challenge lies in how to make use of available national indicators, which tend to better capture local realities.

The methodology offered by the GEP measurement framework is flexible enough that it can overcome these practical challenges. A separate publication presents an application of the methodology at the global level, where progress was measured for a sample of 105 countries between 2004 and 2014. The purpose behind the application is to Beta test the methodology and learn about its different tradeoffs and challenges. This, in turn, can help improve the methodology's design, and most importantly, enrich the overall process of green economy policy making analysis.[26]

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ANNEX I – FORMALIZATION OF THE THEORETICAL FRAMEWORK

A. THE BASIC MODEL

Consider a society whose performance is to be evaluated across several dimensions, with respect to a vector of targets or reference values that have been previously set.

Let $K = \{1, 2, \dots, k\}$ denote a set of dimensions, with $k \geq 2$. A realization for this society is a vector $\mathbf{q} = \{q_1, q_2, \dots, q_k\}$. The entry qj is a real number that describes the value of variable *j*. It is implicitly assumed that all dimensions can be approximated quantitatively by real numbers. There is a parameter vector of reference values $\mathbf{s} = \{s_1, s_2, \dots, s_k\}$ that describes the targets fixed for the different dimensions. How those thresholds are set will depend on each specific problem (this question will be discussed later, when addressing the construction of the GEP Index).

An evaluation problem, or simply a ***problem***, can be identified with a pair of vectors (**q**, **s**). In order to evaluate society's outcomes q relative to a vector of targets s, a continuous function *F* that associates to each problem (**q**, **s**) a real number, *F*(**q**, **s**), which provides information on the fulfilment of the objectives, must be identified. This function is obtained from an intuitive set of properties described below.

A.1 Properties

The first property, neutrality, says that all objectives are equally important (a more general case is referred to later on). This implies that rearranging the ordering of weighted realizations and targets does not affect the evaluation. Formally:

› **Neutrality:** Let (**q**, **s**) be a given problem and let *p*(**q**), *p*(**s**) denote a permutation applied to the elements of **q** and **s**. Then, *F*(**q**, **s**) = *F*(p(**q**), p(**s**)).

The second property, normalization, determines a scale for the evaluation function. It says that the value of the function is zero when all outcomes are zero and the value is equal to one when all outcomes exactly match the targets.

› **Normalization:** Let **0** denote the vector whose components are equal to zero. Then, *F*(**0**, s) = 0, *F*(**s**, **s**) = 1.

The last property, additivity, establishes conditions on the behaviour of the evaluation function when the vector of achievements changes from **q** to **q'** = **q** + **c** for some k-dimensional vector **c** (which may include positive and negative numbers). The property requires the change of the index to correspond to the evaluation of that change by the very same evaluation function. This is a very natural property that is most useful when the data are collected from several sources, or across different time periods, or when there are mistakes to be corrected. The new data can be integrated by simply computing the value of that change and adding the result to the original value of the index. Formally:

› **Additivity:** Let (**q**, **s**) be a problem, and let **q'** = **q** + **c**. Then, *F*[(**q** + **c**),**s**] = *F*(**q**,**s**) + *F*(**c**,**s**)

The following result is obtained:

Theorem: *A* continuous function *F* satisfies the properties of neutrality, normalization and additivity, if and only if:

$$F(\boldsymbol{q}, \boldsymbol{s}) = \frac{1}{k} \sum_{j \in K} \frac{q_j}{s_j} \qquad [A.1]$$

Moreover, all these properties are independent.

This theorem shows that assuming the principles of neutrality, normalization and additivity amounts to choosing a precise and very intuitive evaluation function: a vector of outcomes (**q**) is evaluated with respect to a vector of targets (**s**) as the arithmetic mean of the relative achievements (the ratios between outcomes and targets).

The case in which different objectives have different importance can be readily handled. Let $\pi = (\pi_1, \dots, \pi_k)$ denote a vector of relative weights that describe the importance of each objective, $\pi_j \geq 0, \forall j, \sum_{j\in K} \pi_j = 1$. Then by making the following change of variable: $y_j = k\pi_j q_j$, the following extension of the former result is obtained:

$$F(\boldsymbol{q}, \boldsymbol{s}; \pi) = \sum\nolimits_{j\in K} \pi_j \frac{q_j}{s_j}$$

Now the property of neutrality is to be understood as "weighted neutrality", saying that any permutation of the variables $y_1, \dots, y_k$ leaves the index unchanged.

A.2 Proof of the characterization result

Theorem: A continuous function F satisfies the properties of weighted neutrality, normalization and additivity, if and only if:

$$F(\boldsymbol{q}, \boldsymbol{s}) = \frac{1}{k}\sum\nolimits_{j\in K} \frac{q_j}{s_j} \qquad [A.2]$$

Moreover, all those properties are independent.

Proof

(i) It is easy to see that function [A,1] satisfies all properties. Let us verify the reciprocal.

For a given problem (**q**, **s**), let **d***j*(a) denote a vector whose elements are all zero except entry ***j*** that is equal to ***a***. Applying repeatedly the property of additivity, we have:

$$F\big((q_1, 0, \dots, 0), \boldsymbol{s}\big) = F(\boldsymbol{d}_1(q_1), \boldsymbol{s}) + F(\boldsymbol{0}, \boldsymbol{s}) = F(d_1(q_1), \boldsymbol{s})$$
$$F\big((q_1, q_2, 0, \dots, 0), \boldsymbol{s}\big) = F(\boldsymbol{d}_2(q_2), \boldsymbol{s}) + F(d_1(q_1), \boldsymbol{s})$$
$$\dots$$
$$F(\boldsymbol{q}, \boldsymbol{s}) = \sum\nolimits_{j\in K} F\left(\boldsymbol{d}_j(q_j), \boldsymbol{s}\right)$$

Let now 1***a*** denote a vector with all entries equal to ***a***. In this particular case, we have:

$$F(\mathbf{1}a, \mathbf{1}t) = \sum\nolimits_{j\in K} F\left(\boldsymbol{d}_j(a), \mathbf{1}t\right)$$

Moreover, neutrality implies:

$$F\big(\boldsymbol{d}_j(a), \mathbf{1}t\big) = F(\boldsymbol{d}_h(a), \mathbf{1}t)$$

Therefore,

$$F(\mathbf{1}a, \mathbf{1}t) = kF\big(\boldsymbol{d}_j(a), \mathbf{1}t\big) \Rightarrow F\big(\boldsymbol{d}_j(q_j), \mathbf{1}s_j\big) = \frac{F\big(\mathbf{1}q_j, \mathbf{1}s_j\big)}{k}$$

Substituting in the equation above, we get:

$$F(\boldsymbol{q}, \boldsymbol{s}) = \frac{1}{k}\sum\nolimits_{j\in K} F\left(\mathbf{1}q_j, \mathbf{1}s_j\right) \qquad [A.3]$$

Now observe that our assumptions imply that function ***F*** is homogeneous of degree 1 in **q**, that is, $(\lambda\boldsymbol{q}, \boldsymbol{s}) = \lambda F(\boldsymbol{q}, \boldsymbol{s})$, for all $\lambda > 0$. Define a new function $\boldsymbol{f} : \mathbb{R} \times \mathbb{R}_+ \to \mathbb{R}$ as follows:

$$f\big(q_j, s_j\big) := F\big(\mathbf{1}q_j, \mathbf{1}s_j\big)$$

As this function inherits the properties of homogeneity and normalization, by letting $q_j = s_j, \lambda = q_j/s_j$, we have:

$$f\left(\frac{s_j}{q_j}q_j, s_j\right) = \frac{s_j}{q_j} f\big(q_j, s_j\big) = 1$$

Substituting into equation [A.2] for all ***j***, we get:

$$F(\boldsymbol{q},\boldsymbol{s}) = \frac{1}{k}\sum_{j\in K}\frac{q_j}{s_j}$$

(**ii**) In order to separate those properties, let us consider the following indices:

$$F^A(\boldsymbol{q},\boldsymbol{s}) = \sum_{j\in K}\frac{q_j}{s_j}$$

It satisfies all properties except normalization.

$$F^B(\boldsymbol{q},\boldsymbol{s}) = min_{j\in K}\left\{\frac{q_j}{s_j}\right\}$$

It satisfies all properties except additivity.

$$F^C(\boldsymbol{q},\boldsymbol{s}) = \frac{q_j}{s_j}$$

It satisfies all properties except neutrality. **q.e.d.**

B. Weighting of the GEP Index in the case of several countries

The objective of this section is to discuss how to make a comparative evaluation of a set of countries ***C***. Now the variables are $y_j^1(i), y_j^0(i), y_j^*(i), t_j(i), \pi_j(i)$ where the term (**i**)

refers to the country in the corresponding set ***C***.

Two types of comparisons among countries can be considered. One refers to comparing countries with respect to a single indicator. In that case, we simply take the values:

$$\frac{dy_j(i)}{dy_j^*(i)}, for\ j \in G, \qquad \frac{d(-y_j)(i)}{d(-y_j^*)(i)}, for\ j \in B$$

and see how those values are in the corresponding countries.

The other type of comparison refers to the corresponding GEP indices. In this case, one has to decide how to weigh each dimension in the different countries. There are two possibilities in this regard: choosing a common weighting system or keeping each country's individual weights.

A common weighting system makes the international comparison more intuitive at the cost of losing the individual traits (that is, the possibility of using this formula to individually evaluate the achievement of the objectives). The most natural choice would be defining those coefficients as a weighted average of the individual coefficients of all involved countries using their population shares. That will produce the following formula for each country i in the set ***C***:

$$GEP(i) = \sum_{j\in G}\pi_j\frac{dy_j(i)}{dy_j^*(i)} + \sum_{j\in B}\pi_j\frac{d(-y_j)}{d(-y_j^*)} \qquad (B.1)$$

where:

$$\pi_j = \sum_{i\in C}\frac{n(i)}{\sum_{h\in C}n(h)}\pi_j(i)$$

where $\pi_j(i)$ is the weight of dimension ***j*** in country ***i***, ***n***(***i***) the population of country ***i*** and ***n***(***h***) is the population of country ***h***, a country which is in the same sub-group as country (**i**) (for example countries that share the same level of development according to the Human Development Index).

The alternative is keeping the individual weights $\pi_j = \frac{\widehat{\pi_j}}{\sum_{j \in J} \widehat{\pi_j}}$), which is the approach adopted for the GEP Index. This option preserves the individual characteristics, allowing for individual evaluation of achievement, but makes it harder to interpret the international comparison. However, the country-specific weighting system can be given a sensible interpretation in terms of ***egalitarian equivalent values***.

Note that each country's individual weights give the (constant) slope of the indifference curves for the corresponding variables, as they define the associated rates of substitution. Actual values determine which indifference curve is considered for each country, from the specific point of realizations. Figure B.1 illustrates the case of two countries, red and blue, with realizations **A** and **B**, respectively, regarding two indicators. The figure makes it clear that the problem is that of comparing those realizations which correspond to indifference curves that intersect, so that one is above the other in one part and below in another.

The egalitarian equivalent approach consists of selecting a ray that intersects both indifference curves and allows one to compare the points in the indifference curves along this ray. Note that those points will always be comparable as they are situated over the same ray and that each point in that intersection is equivalent (i.e. yields the same evaluation) to the corresponding original value.

Interestingly enough, it can be shown that keeping independent weights for the different countries (the approach adopted here) amounts to selecting the 45º line as the appropriate ray, as shown in Figure B.2. What is the meaning of taking the diagonal ray? The diagonal ray represents, in the GEP Index context, the case in which the achievements meet the targets in all dimensions. Therefore, using country-specific weights to aggregate dimensions amounts to using the egalitarian equivalent approach, in which the 45º line is associated with full achievement of targets.

Figure B.1: *Comparing realization A and B with linear indifference curves*

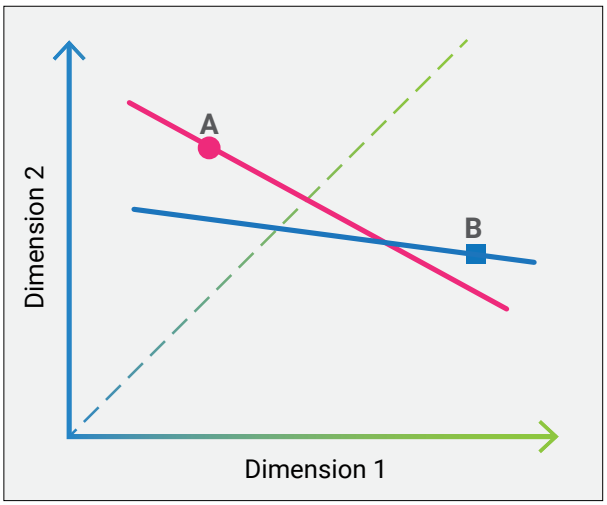
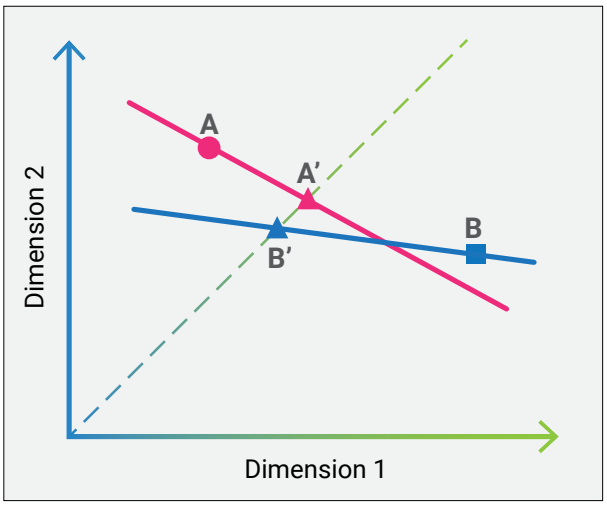


Figure B.2: *Comparing realizations A and B alone the 45˚ line (when targets are met in all dimensions)*



C. Aggregating the information from the dashboard and the GEP Index, creating the GEP+ (The Protective Criterion)

A comparison between the GEP Index and the information from the dashboard is made according to a symmetric and convex order $\succ$ on the space $\mathbb{R}^{J+1}$, of achievements, which satisfies the following principles:

1. Pareto

Given two achievement profiles x, z in $\mathbb{R}^{J+1}$, $x \geq z$ implies $x \succ z$.

2. Independence of Identical Consequences

Let x and z be two achievement profiles with $x_k = z_k$ for some $k \in \{1, \dots, J+1\}$. Then $x \succ z$ if and only if $x_{-k} \succ z_{-k}$.

3. Independence of Duplicated Consequences

Let ***x***, ***z*** be such that, for some ***k***, ***m***, $x_k = x_m$ and $z_k = z_m$. Then $x \succ z$ if and only if $x_{-k} \succ z_{-k}$ if and only if $x_{-m} \succ z_{-m}$.

Define the difference set to be equal to the set of dimensions $\mathcal{D}(x, z)$ on which the index-dashboard profiles ***x*** and ***z*** differ, that is:

$$\mathcal{D}(x, z) = \{k \in \{1, \dots, J+1\} : x_k \neq z_k\}$$

The following is a consequence of Theorem 3 in *Barberà and Jackson (JET, 1988)*.

Theorem (The Protective Criterion)

Let $\succ_P$ be a symmetric and convex order on $\mathbb{R}^{J+1}$ that satisfies Pareto, Independence of Identical Consequences and Independence of Duplicated Consequences. Then $x \succ_P z$ if and only if

$$\min_{k \in \mathcal{D}(x,z)} x_k > \min_{k \in \mathcal{D}(x,z)} z_k$$

This ordering, like the min ordering, compares alternatives in terms of their worst case but only taking into account the dimensions on which they differ.

The application of the Protective Criterion for the construction of the GEP+ requires us to define the achievement profile for each country as follows:

1. The country's achievement for each stock ***j*** in the dashboard is given by the expression

$\frac{dK_j}{dK_j^*} \cdot \frac{t_j}{K_j^0}$, if we wish for stock K_j to grow,

and

$\frac{dK_j}{dK_j^*} \cdot \frac{K_j^0}{t_j}$, if we wish for stock K_j to shrink.

The first term in the computation of a country's achievement in stock ***j*** is the country's degree of progress as calculated in the dashboard. The second term in the computation of such achievement is the importance of that progress, which is calculated using the same principles employed in the determination of the weights of the GEP. Put simply, the country's achievement for each stock ***j*** in the dashboard is given by the expression

$$Progress(j) \cdot Importance(j)$$

2. The country's GEP achievement is given by the expression

$GEP \cdot \overline{Importance}$, where

$$\overline{Importance} = \frac{1}{I} \sum_{i=1}^{I} Importance(i)$$

The achievement profile for ***each country*** is then the (*J*+1)-vector given by the GEP achievement and the achievement for each of the stocks in the dashboard, as calculated above.

To understand how one could use the information in the achievement profile of two countries to calculate the GEP+, consider the case where x and z are the achievement profiles of two countries. Then it can be argued that if x is in a more favorable position than z it must be the case that the worst achievement in x is greater than the worst achievement in z. This is the principle of ***Priority to the Worst Achievement*** and is how the ranking of overall progress, GEP+, is constructed.

NOTES

[1] The current beta test application of the methodology has 14 direct links to 10 of the 17 SDGs. For an overview of the links between the SDGs and the GEP measurement framework, see PAGE (2017), The Green Economy Progress Framework- Application (2017).

[2] See Section 2 for a definition of this "new generation of capital".

[3] See PAGE (2017). The Green Economy Progress Framework – Application.

[4] There is a potential for the GEP Measurement Framework to cover more selected SDGs and targets. The flexibility of the framework allows for the inclusion of many of the SDGs indicators related to green economy. This is particularly important for applications of the framework at the country level where a richer set of indicators may be available.

[5] United Nations (2012).

[6] See GGKP (2016) for a complete review of main approaches and indicators as well as the identification of research gaps.

[7] A significant literature review was conducted prior to this project to assess the landscape of existing indices related to sustainable development. A gap was found in the area of the measurement of green economy progress, which was one of the motivations for developing the GEP Measurement Framework. See Pineda and Galotto (2015) for more information.

[8] This section is largely based on "An Emerging theory of an Inclusive Green Economy" (Sheng, 2016).

[9] These assets include: (a) renewable natural capital (e.g. freshwater, forests, and fisheries); (b) low carbon, resource efficient physical capital (e.g. solar panels, wind turbines, public transport systems, and waste treatment/recycling/re-manufacturing facilities for a circular economy); (c) human capital with green job skills (e.g. installation, operation and maintenance of energy efficient equipment); (d) and social capital (e.g. equitable access to justice, social services, and opportunities, social safety nets, and social protection floors).

[10] See Section 2.2 for a definition of progress.

[11] The current beta test application of the methodology has 14 direct links to 10 of the 17 SDGs. For an overview of the links between the SDGs and the GEP measurement framework, please see The Green Economy Progress Framework: Application (2017).

[12] To ensure consistency throughout UN Environment's work, the country-tailored version of the GEP measurement framework will be integrated into UN Environment's framework on green economy indicators under PAGE. This framework has been designed to link indicators with the integrated green economy policymaking process.

[13] In this context, "valid" is to be understood as "reasonable" or "acceptable".

[14] Based on technical documents prepared by Carmen Herrero, Antonio Villar and Eduardo Zambrano (2016), Antonio Villar (2011), and on technical discussions with José Pineda and Gisèle Mueller.

[15] See: http://hdr.undp.org/sites/default/files/hdr2015_technical_notes.pdf

[16] In line with the "Beyond GDP" approach (See Report by the Commission on the Measurement of Economic Performance and Social Progress (Stiglitz et al., 2010)) and the recent criticisms of using GDP as a (or the only) measure of well-being, the GEP measurement framework has deliberately decided not to use measures of GDP in the calculation of

progress. The main reason for this decision is that GDP not only measures green but also 'brown' economic activities, which do not support the transition towards an Inclusive Green Economy. The inclusion of indicators such as green trade, green innovation and renewable energy allows the GEP index to capture (although partially) the green components of GDP. In addition, the inclusion of indicators measuring the access to basic services, health and education allows the GEP index to capture the positive aspects that higher economic growth will bring to promoting an Inclusive Green Economy.

[17] See Annex I.A for a discussion of properties in the basic model and a proof of the characterization result.

[18] It is important to note that for a country experiencing regress in an indicator in which it is initially disadvantaged with respect to the relevant threshold, this weighting system will imply that regress will have a significant weight. In other words, the weighting system provides signals on policy priorities.

[19] The first weighting indicates the relevance of the progress made in each of the areas, as captured by the indicators; the second weighting, however, makes it possible to establish comparisons within and across countries (given that the sum of all weights is equal to 1). See Annex I.B for a discussion of weighting for the GEP index in the multiple country case.

[20] For a method to combine an assessment of development adjusted by sustainability, see Pineda (2012).

[21] This implies a non-decreasing discounted utilitarian sum of generational utility, i.e. economic paths along which intergenerational well-being does not decline. For more information, see Marc Fleurbaey and Didier Blanchet (2013).

[22] See more on this from Fleurbaey and Blanchet (2013, p. 21).

[23] Fleurbaey and Blanchet (2013, p. 50).

[24] This is so because the Protective Criterion (see Annex I.C), like the leximin, does not admit a real-valued representation due to the lack of continuity of the preference ordering. For proof see the example of Moulin (1998, p. 34).

[25] This method of creating the ranking limits the incentives for substitution across equally important aspects of an Inclusive Green Economy; it also gives incentives to progress in all aspects and penalizes any partial view that only concentrates on a few policy areas.

[26] See PAGE (2017). The Green Economy Progress Framework – Application for an application of the methodology at the global level.

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For further information:

PAGE Secretariat
UN Environment
Economics and Trade Branch
11-13 Chemin des Anémones
CH-1219 Chatelaine-Geneva
Switzerland
page@unep.org

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