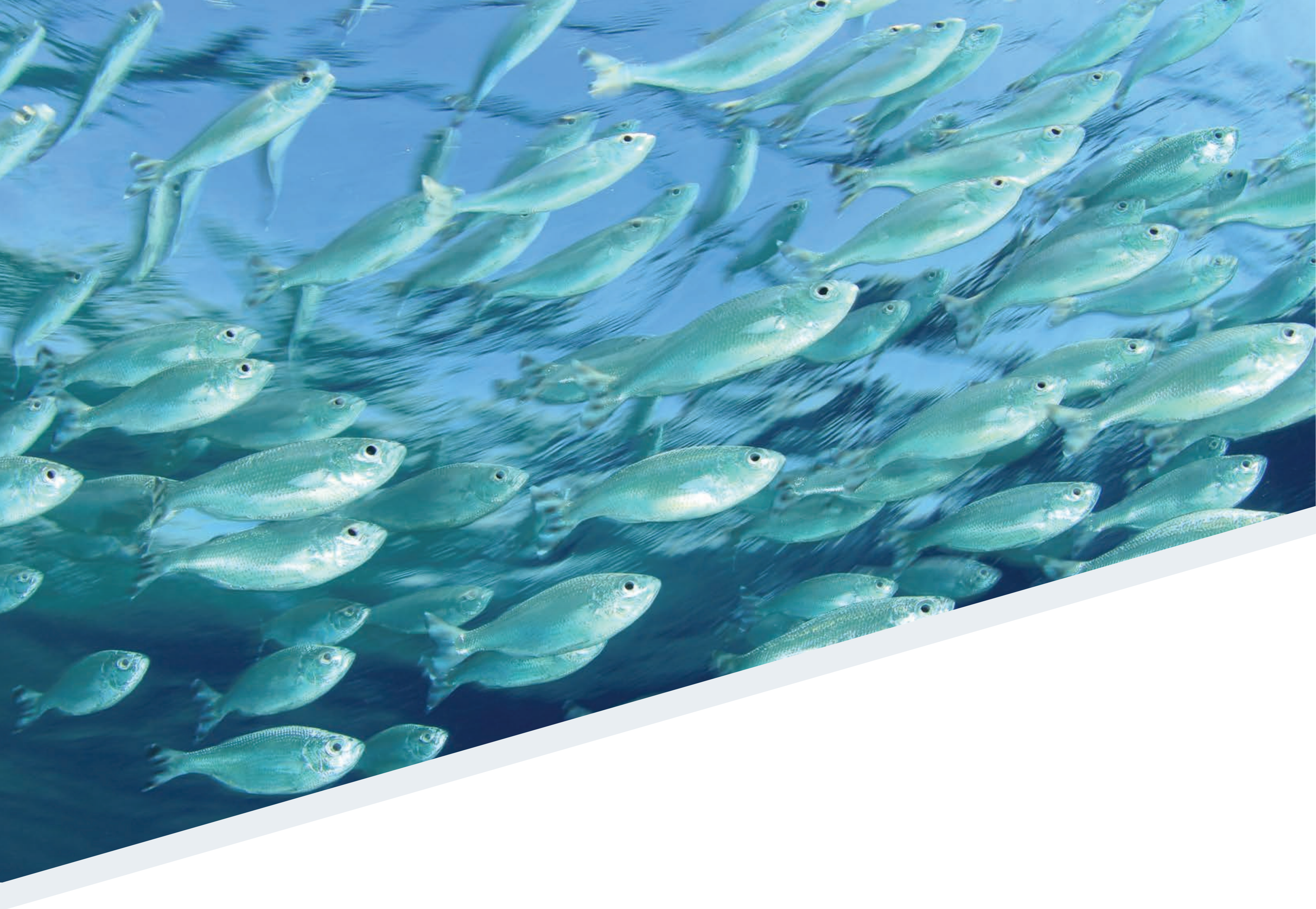

GREEN GROWTH
Knowledge Platform

Measuring Inclusive Green Growth at the Country Level

Taking Stock of Measurement Approaches and Indicators

GGKP Research Committee on Measurement & Indicators

Working Paper 02 | 2016

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Ulf Narloch, Tomasz Kozluk, Ainsley Lloyd

February 2016

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The Green Growth Knowledge Platform (GGKP) – a global partnership of leading organizations – identifies and addresses major knowledge gaps in green growth theory and practice. Established by the Global Green Growth Institute (GGGI), the Organisation for Economic Co-operation and Development (OECD), the United Nations Environment Programme (UNEP) and the World Bank, the GGKP includes over 35 partner organizations. For more information, visit www.greengrowthknowledge.org.

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Executive Summary

Inclusive green growth (IGG) combines economic, social and environmental dimensions, which increases the complexity of measurement and monitoring. No single indicator is enough to track progress towards IGG. There is unlikely to be a standardized, "one-size-fits-all" way to track it. Countries may hence choose different measurement approaches and indicators, depending on their priorities and capacities. Following GGKP (2013), we identify five main themes of relevance for measuring IGG: natural assets, resource efficiency and decoupling, resilience and risks, economic opportunities and efforts, and inclusiveness.

Among these themes, granular environmental, economic and social information can be combined in ways broadly classified along four approaches, namely, a dashboard of indicators, composite indicators, environmental footprints, and "adjusted" economic measures (e.g. green GDP, adjusted net savings and extended wealth). Most of the reviewed indicators focus on two of the three IGG dimensions – either the economy and the environment or the environment and the social dimension. Combining the two dimensions in a sound and meaningful way can be challenging, both methodologically and for interpretation, and approaches that cover the three IGG dimensions (i.e. inclusive, green and growth) are mainly dashboards and composite indices.

Several main lessons can be drawn from recent applications. First, dashboards seem to have been most widely used for measuring IGG at the country-level, and frameworks and indicators have been developed by various developed countries. Second, composite indices measuring IGG progress are not (yet) readily available, although a number of environmental indices exist and have been applied in various country contexts to measure aspects of relevance for IGG. Third, footprints have rarely been applied at the national level but can be an important ingredient of IGG measurement frameworks. Finally, adjusted economic measures that account for environmental information have advanced considerably (e.g. through natural capital accounting). Significant gaps, however, remain as existing approaches do not comprehensively cover natural resource depletion and environmental degradation.

A review of global data for IGG indicators shows that a great variety of information tracks current status and changes over time of natural assets. Qualitative aspects have limited coverage, and data on economic costs/ benefits, accessibility and optimal or sustainable use are rare. Data coverage on resource efficiency and use focuses primarily on the production side and is usually available at fairly aggregated levels. Although several data sources that measure some aspects of economic resilience to ecological risks exist, truly comprehensive approaches and metrics to capture this multidimensional concept are missing. Indicators measuring economic opportunities and efforts (including policies) are scarce and underdeveloped, suffering from poor coverage. Definitional and conceptual issues are among the main explanations. There is a notable lack of data sources and indicators that capture the social dimensions of green growth and the distribution of costs and benefits of environmental policies among different groups of society.

Based on this stock-taking we identify the following gaps for applying the above measurement approaches and covering the five measurement themes: (i) economic values of stocks and flows of natural assets; (ii) qualitative dimensions of natural assets; (iii) sustainable use or extraction of natural assets; (iv) combining micro-level economic and environmental data; (v) resilience of socioeconomic systems to ecological shocks; (vi) tracking of employment effects, investment and other economic effects, in particular on the opportunities side; (vii) aggregate impacts of environmental policies; and (viii) distributional impacts of environmental changes and policies (i.e. who is affected in a positive or negative way).

The lack of sufficient data coverage across countries and time should not eliminate these aspects from IGG measurement frameworks. Instead, demand for such indicators can spur investment in research and monitoring systems that trigger data collection. If such investment is not made early enough, coverage and concepts may not develop.

Promisingly, innovative data collection methods, strategic collaboration with the private sector and new statistical frameworks, such as the System of Environmental-Economic Accounting and the indicator framework for the Sustainable Development Goals (SDGs), provide opportunities to generate new data for IGG measurement. For moving forward it will be important to prioritize the measurement gaps and mobilize investment for indicator development and data collection.

Contents

1. Setting the stage: inclusive green growth

Economic development has improved the living conditions of people around the globe, but more inclusive growth is needed to achieve future development goals. Over the past two decades, the number of people living on less than $1.25 a day has halved to around one billion people, or 14.5 per cent of the world's population in 2011(World Bank Group, 2014). Accordingly, the Millenium Development Goals (MDG) target to halve the number of people in extreme poverty between 1990 and 2015 has been met ahead of time, but on many other MDGs, especially in health and education, developments are lagging. And while the bottom 40 percent enjoyed more rapid income growth than the average population, their welfare remains much lower than in households in the top 60 percent and many still lack access to basic services (World Bank Group, 2014). Continued and more inclusive growth is needed to eradicate poverty and achieve shared prosperity in developing and developed countries alike (OECD, 2011a; UNDP, 2013; World Bank Group, 2014).

In a world of rising population and living standards, and in light of planetary boundaries, environmental sustainability is becoming more important on the agenda of policymakers. If left unchecked, the deterioration of the natural environment will pose a threat to further improvements to inclusive economic growth. Many countries are affected by interlinked challenges, such as air and water pollution, soil degradation, water scarcity, collapsing fish stocks, biodiversity loss or climate related risks (World Bank Group, 2014, OECD, 2012, IPCC, 2014a). Some scientists claim that we have already exceeded the "safe zone" for some of the planetary systems.[1] And without intensive mitigation actions, a temperature rise by 4C above pre-industrial levels becomes possible by the end of this century (Jobbins et al., 2014).

Inclusive green growth (IGG) attempts to provide a solution to the joint objectives of economic growth, environmental sustainability and social inclusiveness. Concepts, such as green growth, green economy, new climate economy and low-carbon development have developed alongside each other, with slightly different definitions. In principle, they are all consistent with each other – requesting that economic development (i.e. growth) is aligned with environmental sustainability (i.e. green) without undermining social equity (i.e. inclusive). The differences concern primarily the coverage of environmental challenges – e.g. whether these are restricted to climate change or more broadly defined (NCE, 2014; OECD, 2012; UNEP, 2011; World Bank, 2012a).

IGG is intended as a way to operationalize sustainable development, combining the economic, social and environmental pillars of sustainability (WCED, 1987). IGG requires a transformation of economies and a transition towards cleaner, low-carbon, resource efficient and resilient economic systems in the long-run. Strategies for achieving IGG will be very different across countries (OECD, 2011b; UNEP, 2011; World Bank, 2012b).

Aspects of IGG are also reflected in the recently adopted Sustainable Development Goals (SDGs) that seek to end poverty, protect the planet and ensure prosperity for all.[2] Goal 8 focuses on promoting inclusive and sustainable economic growth, and it includes targets for increasing resource efficiency in consumption and production and decoupling economic growth from environmental degradation. Many other targets also play an important role for IGG: achieving sustainable production and consumption patterns (Goal 12); attaining sustainable food production (Goal 2); realizing sustainable water management (Goal 6); creating a sustainable energy supply (Goal 7); making cities inclusive, safe, resilient and sustainable (Goal 11); stabilizing the climate (Goal 13); and protecting oceans (Goal

[1] http://www.stockholmresilience.org/21/research/research-programmes/planetary-boundaries.html
[2] http://www.un.org/sustainabledevelopment/sustainable-development-goals/

14) and land (Goal 15). For the SDG implementation there is also a new impetus to design a global monitoring system and identify indicators for the different targets.

Designing policies to achieve IGG requires measurement approaches and indicators to track challenges and progress. Conventionally, economic progress is measured primarily by Gross Domestic Product (GDP), focusing particularly on economic growth from one period to the next. GDP considers aggregate income (a flow measure) without accounting for the state of assets used to generate it or the distribution of income. Hence, an economy that accomplishes GDP growth by exhausting its assets cannot be distinguished from one that grows by using its assets – natural, physical, human or financial – efficiently and sustainably. Measuring progress towards IGG hence requires approaches and metrics that go beyond GDP and measure the inclusiveness and sustainability of economic progress.

This paper aims to improve the understanding of tools available for measuring IGG. There have been a number of recent papers on IGG measurement that have developed measurement frameworks and identified potential metrics (UNEP, 2012a, 2014; UNESCAP, 2013; OECD, 2014; GGKP, 2013), but a comprehensive stocktaking of existing measurement approaches and indicators is still missing. Building on existing frameworks for IGG measurement (GGKP, 2013), this paper adds to the existing work in three ways. First, it outlines main measurement themes and aspects relevant for IGG (section 2). Second, it reviews measurement approaches and indicators available for tracking progress towards IGG (section 3). And third, it identifies the main gaps where investments research, indicator development and data collection are needed (section 4).

The review will inform a broader discussion on measurement needs of IGG policymaking and will help to facilitate new research on the interactions between economic growth, social development and environmental sustainability.

2. Measuring inclusive green growth

IGG is a multi-faceted concept covering multiple interlinked dimensions – economic, social and environmental. As such, IGG measurement cannot be seen outside the context of general economic and social progress measurement, and in this sense tracking "classical" economic growth, environmental and inclusiveness concepts remains part of IGG. The focus of this report, however, is on measuring interactions of the environment with economic and/ or social dimensions, as opposed to broader socioeconomic measurements, which are already well-documented and developed.

The analysis has been divided into five main measurement themes: (i) natural assets underpinning economic activities, (ii) natural resource efficiency and absolute decoupling from economic growth, (iii) socioeconomic resilience to ecological risks, (iv) economic opportunities and efforts related to environmental policies, and (v) inclusiveness of environmental policies.

The relative importance of these different measurement themes is dependent on regional contexts and the priorities and needs of countries. For example, in fast-growing Asian and Pacific nations, such as China, where development needs are still pressing, issues related to equitable access to resources, energy and resource efficiency, pollution and emissions control are increasingly high on the agenda (UN ESCAP, 2013; World Bank & DRC, 2012). In resource-rich African countries, the efficient and sustainable management of natural assets could be of priority concern (AfDB, 2012). In Latin America, with a large urban population and critical ecosystems, urban development and transport as well as land and water management may be viewed as critical metrics for IGG (World Bank, 2013). In low-lying countries in South Asia with large coastal populations that are highly vulnerable to climatic impacts resilience may be a top priority (Harmeling & Eckstein, 2012).

Hence no single indicator will be able to adequately track progress towards a multi-faceted, country-specific concept such as IGG. Furthermore, as is discussed below, the type of indicators applied depends on the purpose of the measurement.

2.1 Measurement purposes

For policymakers, IGG measurement can serve a range of purposes along the main stages of the policymaking process: objective setting; planning, design, and implementation; and monitoring and evaluation (UNEP, 2014):

- **Diagnostics and objective setting - What is the problem?** Diagnostics rely on approaches and indicators that measure the present state, changes over time and future trends. They focus on outcomes, such as expected climate change or health consequences of air pollution, and their drivers, such as emissions. They serve to identify challenges and opportunities that can induce the formulation of respective policy priorities and goals. These can include establishing a long-term vision for IGG, developing baselines against which to compare developments over time and defining long-term targets aligned with domestic priorities (Mediavilla-Sahagun and Segafredo, 2014).
- **Planning, and design - What should we do?** Based on the identified priorities, solutions are to be formulated, designed and implemented. Measurement helps to inform the choice of policy responses. For example, if the reduction of CO2 emissions is a goal, policies could focus on decarbonizing the energy system (e.g. inducing low-carbon energy supply or increasing energy efficiency).
- **Monitoring and evaluation – How do we perform?** Once priority policies are identified and measurable actions are implemented indicators can be applied to track progress and assess impacts of policy action, such as electricity production from renewables or the improvement in energy efficiency over time. These indicators also assist in assessing whether further policy interventions, or mitigating actions, are required to achieve the underlying policy objectives.

2.2 Green growth measurement themes

While a particular country's IGG priorities and related measures are context dependent, a number of measurement themes and indicator options have been identified to address this heterogeneity (GGKP, 2013).

In this paper we extend and refine the initial GGKP (2013) classification to arrive at five main themes of relevance for measuring IGG: (i) natural assets, (ii) resource efficiency and decoupling, (iii) risks and resilience, (iv) economic opportunities/ efforts, and (v) inclusiveness. The distinction among themes is not strict, so that measurement concepts may fall within more than one category. Moreover, there is no hierarchy among themes, and their importance may vary depending on country-specific circumstances.

Accordingly, the five themes are described in greater detail below, and examples of what could be measured within them are specified. Examples of existing indicators to measure these aspects outlined within the different measurement categories for each theme are provided in the Appendix to the present document (see table A1-A5) and further discussed in section 3.2.

- **Natural assets** relate to the natural resources used to generate economic growth and ecosystem services that support economic activities. This theme can involve issues related to land and soil, forest and timber, water, minerals and energy resources, fish stocks, and air and climate (table 1). Indicators can cover the total available biophysical stock of natural assets

and changes over time, their quality and respective economic values, risks related to depletion or scarcity, or threshold limits, such as planetary boundaries.

Table 1. Examples of measurement categories and aspects within natural asset theme

Measurement Categories	Aspects Measured
Land And Soil Resources	Agricultural land area and value
	Land degradation (e.g. topsoil loss or change in net primary productivity)
Forests And Timber	Forest area and forest cover change
	Value of timber stocks
	Value of forest resource depletion
Water Resources	Available renewable freshwater resources
	Areas/ population exposed to water scarcity
	Water resources exposed to harmful pollution levels
Minerals And Energy Resources	Available stocks and reserves (e.g. minerals, crude oil, gas)
	Value of remaining stocks and reserves
	Value of energy extraction and depletion
Oceans And Fish Stocks	Sustainable seafood production
	Proportion of fish stocks overexploited or collapsed
	Value of fish stock depletion
Biodiversity	Species abundance
	Number of threatened species
Air	Air pollution
	Cost of air pollution
Climate	CO_2 and other GHG emissions
	Remaining CO_2 or GHG emissions budget to stay within certain climate goals

- **Resource efficiency and decoupling** relates to how efficiently (or wastefully) economic outputs are produced and consumed. Efficiency indicators focus on comparisons of economic outcomes with the environmental inputs or pollution associated with production or embedded in consumption. Production-based environmental and resource productivity indicators account for environmental inputs or pollution directly linked to domestic production. Demand-based (or footprint) indicators paint a fuller picture, accounting for the environmental effects related to the full production chain for domestically consumed goods. Such indicators of decoupling show the development of environmental pressures in absolute or per capita terms.

Table 2. Examples of IGG categories and aspects within resource efficiency theme

Measurement Categories	Aspects Measured
Productivity/ Efficiency And Resource Preservation	Natural resource productivity
	Environmentally adjusted multifactor productivity
	GHG intensity and GHG footprint
	Energy efficiency and energy footprint
	Land productivity and biodiversity damage potential caused by direct and indirect land use (“biodiversity footprint”)
	Water intensity; nitrogen balances and water footprint
	Material productivity and material footprint
Waste	Waste generation
	Waste collection
	Waste treatment
Recycling And Renewables	Reuse and recycling rates (households, construction sector and phosphorus, among others)
	Use of renewables

- **Risks and resilience** relates to how resilient the economic growth process is to ecological shocks and risks – especially those related to pollution, degradation, natural disasters, and climate change. If resilience is low, countries are more likely to experience the negative impacts (e.g. fatalities and economic damages). These impacts depend on the exposure (i.e. presence of people, livelihoods and assets that could be adversely affected, and the characteristics of those adversely affected) and vulnerability (i.e. the degree to which a system is susceptible to, or unable to cope with, the adverse effects) of people and economic systems to the climate or disaster hazard (IPCC, 2014). Resilient systems are more able to respond and adapt to impacts and recover from them. The IPCC defines resilience as “[t]he capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning and

transformation" (IPCC 2014). The latest Sendai Framework for Disaster Risk Reduction defines resilience as the "ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner" (WCDRR, 2015).

Table 3. Examples of IGG categories and aspects within resilience and risks theme

Measurement Categories	Aspects Measured
Climate And Disaster Risks Impacts	Fatalities (loss of life, injured, homeless)
	Economic damages
	Propensity to experience climate and disaster impacts
Exposure And Vulnerability To Risks	People/ assets in high-risk areas (e.g. low-elevation coastal zones)
	Population with exposure to harmful levels of air pollutants
	Economic production sensitive to environmental impacts (e.g. agricultural production in water-scarce areas)
	Assets vulnerable to environmental and climate risks
	Adoption of climate resilient building standards
	People with access to early warning systems
	People with climate-risk insurance
Responsiveness/ Adaptation	Government action for disaster risk prevention
	Government capacity to manage disaster risks
	Time to rebuild/ reconstruct physical capital

- **Economic opportunities and efforts** relate to the adoption and implementation of policies, enabling transformation towards IGG as well as tracking the transformation itself. Many green policies aim for such structural transformations, and hence their outcomes are often difficult to measure in the short-run. Instead, a notion of the opportunities created and the efforts made to facilitate such transformations can and should be accounted for.

Table 4. Examples of IGG categories and aspects within economic opportunities and efforts theme

Measurement Categories	Aspects Measured
Environmental Regulation And Planning	Environmental action plan or strategy in place
	Measures of environmental policy stringency
	Extent of protected areas

	Environmental standards
	Renewable energy feed-in tariffs
	Adoption of environmental accounts
	Number of international environmental treaties signed
Environmental Taxes And Government Spending	Environmentally related taxes
	Fossil fuel subsidies
	Public environmental expenditure
Innovation And Business Environment	R&D expenditure (green, total, public and private)
	Green patent counts
Green Transformation/ Opportunities	Green investments (e.g. renewables, public and private)
	Green jobs
	Value added of environmental goods and services sectors
	Adoption of certified products from sustainable value chains (e.g. as market share or number of companies)
	Exports of environmental goods and services sectors

- **Inclusiveness** relates to the social aspects of green growth, measuring how the costs and benefits of environmental policies are distributed among different groups. This theme can include some of the measurement aspects of other themes, but explicitly covers distributional aspects by measuring which households, groups or communities have access to environmental amenities, who is exposed to environmental risks, and who can participate in environmental decision-making and incur the benefits/ costs of green policies.

Table 5. Examples of IGG categories and aspects within inclusiveness theme

Measurement Categories	Aspects Measured
Access To Environmental Goods And Services	Air pollution (exposure by socioeconomic group)
	Water services (access by socioeconomic group)
	Sanitation services (access by socioeconomic group)
	Sewage treatment (access by socioeconomic group)
	Modern energy (access by socioeconomic group)

Participation In Environmental Decision-Making	Representation in environmental agencies and bodies (e.g. by minority, location, gender)
	Control over environmental resource(e.g. land) by social groups (e.g. minorities, indigenous people, gender)
Distributional Impacts Of Environmental Policies	Distribution of costs and benefits of energy subsidies or environmental taxes, e.g. focusing on low-income groups
	Types of jobs created and destroyed, skill requirements
	People benefiting from payments for ecosystem services

These aspects are illustrative examples rather than a prescriptive set of indicators that will be applicable in all countries. The aim of the selected indicators is to ensure they meet the specific needs of a country, which can vary as demonstrated in a recent UNEP study identifying IGG issues and indicators for Ghana, Mauritius and Uruguay (UNEP, 2015).

2.3 Measurement approaches

Tracking progress towards IGG requires measurement across different themes and sectors. There are a wealth of environmental, economic and social indicators that can be relevant for IGG. In practice, decisions need to be made on both the approach and selection of indicators to inform policymaking, particularly given that measuring, processing, interpreting and communicating information all come at a cost.

Granular environmental, economic and social information can be combined in ways broadly classified along four lines: dashboard sets of indicators, composite indicators, footprints, and “adjusted” economic indicators. These four approaches combine information on the interactions among the economy, environment and inclusiveness in different ways (see figure 1). The classification is directly adopted from the seminal work of Stiglitz, Sen and Fitoussi (2010) on the measurement of sustainability, where the classifications and their respective strengths and weaknesses are also outlined:

- **Dashboards** are sets of metrics representing information from various areas related to IGG, such as environmental, economic and social as well as combinations of these. Dashboards can contain very different types of indicators, expressed in different units and with various relations to IGG. In fact, they often include indicators from the other classifications, such as composite indices. Dashboards allow for a broad assessment, which is in line with the multidimensional nature of IGG. Dashboards do not usually impose decisions on the importance of individual indicators or the relationships among them (e.g. trade-offs). In principle, it is up to the user to select and emphasize the most relevant indicators from a dashboard. This implies that they are more in line with the idea of “strong” sustainability, where each of the important dimensions of IGG need to be monitored and one is not assumed to be a substitute for another (Neymayer, 2003). The use of different units also implies that dashboards can do without rigid and difficult assumptions necessary to convert units to reach a common metric. Similarly, it allows explicit differences in the measurement horizons or areas (e.g. regions) regarding each single indicator. For example, dashboards can easily combine national data with data on regions under stress. The breadth and flexibility of dashboards also has downsides, primarily related to communication. A large number of different indicators may require an explicit interpretation effort to draw an overall trend. The large number of dimensions makes general international comparison difficult, even if

comparisons on each single indicator can be highly meaningful. An attempt to limit this problem is to reduce the dashboard to a subset of headline indicators (OECD, 2011b, 2014), but this can entail difficult choices and ultimately omission of important dimensions for individual countries.

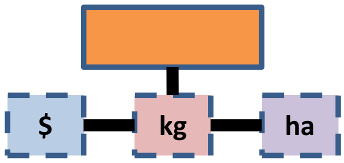
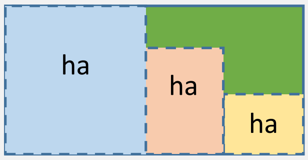
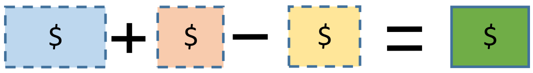
- **Composite indices** aggregate different metrics into one by scoring and weighting the underlying indicators. Single composite indices are, therefore, easier to communicate and allow straightforward comparisons across countries and time. Through weighting and aggregation composite indices assume that there is a certain relationship among the underlying components (Nardo et al., 2008). This is in line with the “weak” sustainability concept, de facto assuming that improvements in one dimension of IGG can offset deterioration in another. In such indices the weighting and aggregation is often rather arbitrary as no straightforward way of valuation of the phenomena captured by different components exists. Moreover, to achieve international and over-time comparability, such aggregation methods are usually fixed – across time and countries - implying little room for priorities to differ or shift across time. Accordingly, the meaning, interpretation and robustness of these indices is often unclear (Ravallion, 2012), making them more suitable as a tool to draw attention to the components that underlie them (Stiglitz et al., 2010).
- **Footprints** aim to indicate if current production/ consumption patterns are sustainable or in line with planetary boundaries (Dao, Friot, Peduzzi, Chatenoux De Bono & Schwarzer, 2015). They provide an easy-to-communicate and appealing metric, for similar reasons as composite indexes. Such indicators can measure selected single phenomena relevant for different sectors or environmental domains, such as greenhouse gas (GHG) emissions or overconsumption of land or water (see Frischknecht, Itten & Büsser Knöpfel , 2013), and they can also aggregate a multitude of economic and environmental issues into a single indicator (e.g. human demand for various ecological resources expressed in land area). Generally, these indicators relate to some kind of threshold or limit that is deemed sustainable. However, in doing so, they may fail to account for future technological progress (Stiglitz et al., 2010). This dilemma can be resolved by allowing for reduction pathways (see, for example, Dao et al., 2015). Furthermore, where thresholds and limits are unknown or uncertain, some minimum standards could be established following a precautionary principle.
- **Adjusted or extended economic measures of GDP, savings and wealth** attempt to correct conventional economic variables by accounting for environmental or less frequently environmental and socially related dimensions. For example, adjusted GDP measurements aim to correct GDP by the value of welfare increasing or reducing activities, such as natural resource degradation, to arrive at an improved, “green” GDP metric. Environmentally adjusted multifactor-productivity growth aims at adjusting conventional productivity measures for the use of natural resources and emission of pollutants (OECD, 2016a). Likewise, extended wealth measures combine various subcomponents of a country’s wealth, including stocks of capital that serve to sustain production in the future, such as natural capital, along with financial, physical and human assets. Extended wealth builds on the concept of green natural accounts and augments standard national accounts measures (World Bank, 2006, 2011) by adjusting gross domestic savings to changes in environmental and human capital valued in monetary terms. The net change is labelled adjusted net savings (Hamilton & Clemens, 1999) or genuine investments (Arrow et al. 2004). The relative strengths and weaknesses of these aggregated measures are similar across adjusted GDP, extended wealth or adjusted savings measures. On the plus side, a single measure can be easily communicated and compared across countries and time. Overall, this approach can provide a comprehensive metric if all changes in natural and other capital forms can be valued accurately. Yet the valuation of non-marketed goods and services (e.g. amenities, scenic landscapes, carbon sinks or ecosystem regulatory functions) is tricky, especially in the presence of non-linearities and threshold effects (e.g. Farley, 2012). In addition, there are often philosophical and political

objections to assigning monetary values to natural and human capital, which some believe cannot or should not be monetized. Moreover, most adjusted measures assume weak sustainability,[3] and for comparison purposes the value of environmental inputs and outputs, and hence the implicit trade-offs among them, are usually assumed constant across countries and time, which may be questionable.

The primary difference among these measurement approaches is linked to the treatment of the multidimensional character of IGG. Dashboards generally make the selection and importance (or weights) attributed to different environmental, social and economic dimensions explicit, often by providing these components in a disaggregated form. This can allow for more freedom to tailor the IGG indicators to the specific needs of a particular country. The disadvantages are also linked to this choice, which can make comparability across countries difficult, if not impossible, and can frustrate efforts to communicate a general message with a multitude of indicators. Composite indices, footprints combining multiple dimensions, and adjusted economic measures integrate a number of different components into a single metric with pre-defined weighting and aggregation methods. Adjusted GDP metrics and the extended wealth approach combine some of the benefits of ease of communication, while providing information about the state of natural, physical and human capital. Both adjusted GDP measurements and extended wealth metrics rely on the principle of weak sustainability, assuming that different environmental, social and economic dimensions can be substituted for one another. Similarly, both are aggregate measures, which usually fail to provide information on the distribution of effects. Moreover, while communication is indeed easier with aggregated measures, this does not necessarily imply that interpretation of these measures is straightforward.

[3] Weak sustainability is a concept linked to the Hartwick rule or resource economics, and assumes that depletion of natural capital can be offset with sufficient investment in other types of capital (e.g. physical or human).

Figure 1. Typology of measurement approaches

Measurement Approach	Final Metric(s)	Combination Of Components
Dashboards	A set of indicators – often measured in different units – without hierarchy	
Composite Indices	Aggregated measure that combines a set of indicators – often measured in different units – through rescaling the individual components and applying weights	
Footprints	A metric that indicates how much of the existing biological capacity (e.g. land) is used to support economic activities and human needs	
Adjusted Economic Measures	A single monetary metric derived through an adjustment of a selected economic variable (GDP, wealth and savings, among others) with monetary valuations of developments related to broader environmental and social sustainability	

Source: Own elaboration based on (Stiglitz et al., 2010).

3. Taking stock of current efforts

There is no standardized, "one-size-fits-all" way to track IGG, and countries will need to choose different measurement approaches and indicators depending on their measurement needs and capacities. Although various measurement frameworks have been developed to fit various regional and socioeconomic realities, there has been general acknowledgement that ultimately the choice of measurement approaches and indicators needs to be tailored to the specific country needs and context (UNEP, 2012a; UN ESCAP, 2013; OECD, 2014; GGKP, 2013). In what follows, we review how existing applications of measurement approaches and indicators can be used to track progress towards IGG.

3.1 Application of measurement approaches

There are a variety of examples of global-level initiatives (i.e. top-down led by international organizations or research institutes) and national-level efforts (i.e. country-led processes) applying dashboards, composite indices, footprints or adjusted economic measures (see table 6). Although many of the applications are not framed in an IGG context, they cover elements of relevance for measuring IGG.

The main lessons from these applications are as follows:

- **Dashboards** seem to have been most widely used for measuring IGG at a country-level, and frameworks and indicators have been developed by various developed countries.
- **Indices** measuring IGG progress are not yet readily available, although a number of environmental indices exist and have been applied in various country contexts to measure aspects of relevance for IGG.
- **Footprints** have rarely been applied at the national-level, but can be an important ingredient of IGG measurement frameworks.
- **Adjusted economic measures** that account for environmental information have advanced considerably, but significant gaps remain as existing approaches do not comprehensively cover natural resource depletion and environmental degradation.

Given the different characteristics of these measurement approaches, they could complement each other and countries could apply a combination of them. It is fair to say that each has its place in measuring IGG. In particular, the recommendation by Stiglitz et al. (2010) to adopt a dashboard approach, but include aggregate measures, such as Adjusted Net Savings and to use it for drawing attention to particular aspects of sustainability, is likely the most valid for IGG measurement.

Table 6. Overview of existing applications of measurement approaches related to IGG

Approaches	Global-Level Initiatives	National-Level Efforts[4]
Dashboards	OECD Green Growth Indicators (OECD, 2011b; 2014) Eurostat Sustainable Development Indicators (Eurostat, 2014)	Korea Green Growth Monitoring Strategy (Statistics Korea) OECD framework indicators prepared by statistical offices in Germany, Czech Republic, Netherlands[5] (OECD, 2014; Statistics Netherlands, 2012) UNIDO/CAF/OECD green growth indicators for LAC (CAF, 2015)
Composite Indices	Green Economy Progress (GEP) Index (UNEP) Global Green Economy Index (Dual Citizen LCC, 2014) Yale Environmental Performance Index (Emerson et al., 2012) WEF Sustainability-adjusted Global Competitiveness Index (Greenhill, 2011)	China Green Development Index (Li, 2013) China's Environmental Performance Index Malaysia's Environmental Performance Index Bhutan's Gross National Happiness Index (Ura, Akire, & Zangmo, 2012)

[4] This is not a comprehensive list; many other green growth relevant indicator efforts can be found in IISD's Compendium of Indicator Initiatives: http://www.iisd.org/measure/compendium/.

[5] While there are more examples of countries that have prepared sets of indicators following the OECD or other frameworks, examples have been chosen here where they have not merely been prepared, but where lessons, results or policy applications have been reported.

	Notre Dame Global Adaptation Index (ND-GAIN, 2013) FEEM Sustainability Index (Eboli, 2011) SOPAC Environmental Vulnerability Index (SOPAC, 2005) OECD Better Life Index (OECD, 2013) Ocean Health Index (Halpern et al., 2012) Happy Planet Index (McGough, 2012) Climate Change Performance Index (Burck, Marten, & Bals, 2015) Low-Carbon Competitiveness Index (Vivid Economics, 2013) Earth Security Index (Earth Security Group, 2015)	
Footprints	Global Ecological Footprint (Global Footprint Network, 2014) CO2 emissions embodied in international trade (OECD, 2015a) Global Resource Footprint (Tukker et al. 2014) Carbon footprint (UNEP, 2014) Water footprint (Hoekstra & Mekonnen, 2012)	Switzerland's Environmental Impact Scotland's Ecological Footprint (Chambers, Griffiths, Lewis, & Jenkin , 2004) AFED Ecological Footprint for Arab Countries (Tolba & Saab, 2012)
Adjusted Economic Measures	Index of Sustainable Economic Welfare (Daly & Cobb, 1989) Genuine Progress Indicator (Talberth, Cobb, & Slattery, 2007) Adjusted net savings (Hamilton & Clemens, 1999) Total wealth including produced and natural capital (World Bank, 2006, 2011) Inclusive wealth (UNEP, 2012)	GPI State of Maryland and Vermont Natural accounts developed, for example, by Australia, Austria, Denmark, Finland, France, Germany, Iceland, Ireland, Italy, Netherlands, New Zealand, Norway, Republic of Korea, Sweden, United Kingdom

	Environmentally adjusted multifactor productivity (OECD, 2016a)	

3.1.1 Dashboards

The OECD framework for green growth indicators is the most frequently implemented green growth dashboard. Based on the idea that green growth is not easily captured by a single indicator, it identifies key issues covered by selected indicators and organizes them into the following themes: natural asset base, environmental and resource productivity, environmental quality of life, economic opportunities and policy responses. Green growth indicators are seen as "markers or milestones on a path of greening growth and of seizing new economic opportunities" (OECD 2011).[6] OECD compiles the data for the 34 OECD countries, as well as Brazil, China, India, Indonesia, Russian Federation, and South Africa. The indicators are available on the OECD website.[7] Work is underway to extend the set to countries in Latin America and the Caribbean, Central and East Asia, and the Caucasus (OECD, 2014). The indicators rely primarily on publicly available economic and environmental statistics and hence have gaps for individual countries. Time series coverage varies by indicator, and a number of indicators remain conceptual in nature and require further conceptual development and data collection.

Eurostat has selected its own set of sustainable development indicators under the following themes: socioeconomic development, sustainable consumption and production, social inclusion, demographic changes, public health, climate change and energy, sustainable transport, natural resources, global partnership, and good governance (Eurostat 2014). Each theme includes headline indicator(s), with the exception of good governance. The dataset covers primarily European countries, as well as the US and Japan, extending back to the 1990s, but is not comprehensive, particularly for the earlier years.[8]

The examples discussed below demonstrate a variety of national-level applications of the dashboard approach (in particular the OECD framework) and the flexibility to adjust it to local needs by adding or removing indicators:

- **OECD Green Growth indicator framework in Europe:** Applications in the Czech Republic, Denmark, Germany, the Netherlands, Slovakia and Slovenia showed that most indicators proposed in the OECD framework can be met using nationally available statistics without additional data collection efforts or significant data gaps (OECD 2014). For some of the more sophisticated indicators, however, such as environmentally adjusted multifactor productivity, natural resource stocks index and soil resources, some data gaps remain. Work is ongoing to fill these gaps (OECD, 2016a, 2016b). Moreover, not all indicators were considered relevant for each of the countries, and as in the latest edition of the Dutch Green Growth Indicators report, the OECD framework is adapted to be more suitable to the local context (Statistics Netherlands 2012).
- **OECD Green Growth indicator framework in Latin America and the Caribbean:** In 2012, the United Nations Industrial Development Organization (UNIDO), the Latin American Development Bank (CAF), and the OECD launched an initiative in Latin America and the Caribbean to establish a policy-relevant IGG measurement instrument (CAF, 2015). The

[6] It should be noted that throughout this paper the OECD framework is used as a means of organizing discussion around green growth themes and global datasets.
[7] http://www.oecd.org/greengrowth/greengrowthindicators.htm
[8] The coverage of Eurostat's Sustainable Development Indicators concerns primarily EU-28, Liechtenstein, Norway, Iceland, Switzerland and Turkey. Starting dates depend on the indicator, ranging from the 1990s (e.g. GHG emissions and energy intensity) to late 2000s (in the case of resource productivity). A large number of observations are missing, in particular for the early years.

program was piloted by Colombia, Costa Rica, Ecuador, Guatemala, México, Paraguay and Peru, with the intention to ultimately expand the effort throughout Latin America and the Caribbean. Each country selected an appropriate set of indicators following the five themes in the OECD general framework, and adjusted the selection of indicators to fit the country context and existing sources of data. In addition, an assessment of the measurability of indicators was conducted in many of the participating countries.

- **Korea's IGG dashboard:** The Republic of Korea adjusted the OECD dashboard approach to monitor progress towards 10 policy directions outlined in their National Strategy and Five-Year Plan (2009-2013), choosing 30 indicators and setting a target for each. The focus is largely on energy and climate, with less weight given to natural assets. The OECD dashboard is augmented by indicators on GHG sinks, energy and food self-sufficiency, spatial indicators of access to public transport and green space, environmental certification for businesses, and government funds for disaster prevention (OECD, 2014).
- **Canada's Environmental Sustainability Indicators (CESI):** Canada produced a country-specific dashboard of environmental sustainability indicators in 2004 to track progress under its Federal Sustainable Development Strategy. The indicators are organized in three thematic areas: (i) air and climate, (ii) water, and (iii) nature. A web-platform allows users to select national-level indicators from the dashboard and display the various observation points, disaggregated at the subnational level.[9]
- **Hawaii Green Growth (HGG) Sustainability Measures:** In January 2014, a start-up project was launched by state government agencies and partner organizations in Hawaii to develop a set of indicators to inform the public on progress towards the targets of the Aloha+ Challenge. The indicators are organized around the following thematic areas: clean energy, local food production, natural resource management, waste reduction, smart growth/ climate change adaptation, and green workforce/ education.[10]

3.1.2 Composite indices

So far, the application of indices for measuring IGG has been limited, but several global-level initiatives to develop an index that explicitly measures IGG have recently emerged:

- **Green Economy Progress (GEP) Index:** The main objective of UNEP's GEP index, which is currently under development, is to capture progress towards achieving an inclusive green economy by tracking changes in flows that characterize inter-linkages between the social, economic and environmental dimensions of sustainable development. The GEP index is, therefore, designed to measure flows that describe a country's performance in terms of progress in creating economic opportunities and a more efficient use of resources, promoting social inclusiveness and preserving environmental quality.
- **Global Green Economy Index (GGEI):** Several iterations of the GGIE have been published by Dual Citizen, a private consulting firm since 2010. The GGEI assesses 60 countries and 70 cities along four themes: (i) leadership and climate change, (ii) efficiency sectors, (iii) markets and investment, and (iv) environment and natural capital (Dual Citizen LLC, 2014). The index targets governments, international organizations, civil society and the private sector. The GGEI attempts to combine conceptually different indicators that are measured based on different methodologies (ranging from CO2 emissions to advocacy by heads of State for green economies) within in its four themes. The index also includes qualitative data from Google searches and media monitoring. Interestingly, a perception survey was launched to poll

[9] http://www.ec.gc.ca/indicateurs-indicators/default.asp?lang=En&n=130FFF78-1
[10] http://www.hawaiigreengrowth.org/priorities/sustainability-measures/objectives

targeted respondents on how they assessed national green performance; it was included in the last GGEI report.

Moreover, other global-level initiatives have developed indices for varying purposes, which cover a number of IGG elements (see table 7). Although the final indices may not be of direct use for informing IGG policymaking, their underlying components and indicators could be used in IGG measurement.

Table 7. Summary of major global-level composite indices

Index	IGG Relevance	Structure	Coverage	Year(s)
Environmental Performance Index (EPI) by Yale University http://epi.yale.edu	Evaluates country performance relative to objective benchmarks Includes relevant aspects of natural assets and resource efficiency Limited economic focus	Includes sub-indicators in 8 themes: (i) Health Impacts (ii) Air Quality (iii) Water and Sanitation (iv) Water Resources (v) Forests (vi) Fisheries (vii) Biodiversity and Habitat (viii) Climate and Energy	178	2006 2008 2010 2012 2014
Global Competitiveness Report And Index - Sustainability Adjusted (GCI) by The World Economic Forum http://www.weforum.org/content/pages/sustainable-competitiveness	Evaluates economic competitiveness adjusted for social and environmental sustainability based on sustainable competitiveness concept Measures institutions, policies and factors that (i) ensure an efficient management of resources to enable prosperity for present and future generations, (ii) that enable all members of society to experience the best	Accounts for sustainability including: (i) Environmental: - Environmental policy - Use of renewable resources - Degradation of the environment (ii) Social: - Access to basic necessities - Vulnerability to economic exclusion	147	2011-2014

Index	IGG Relevance	Structure	Coverage	Year(s)
	possible health, participation and security; and to maximize their potential to contribute to and benefit from the economic prosperity of the country (Greenhill, 2011)	- Social cohesion		
Notre Dame Global Adaptation Index (NG-GAIN) http://index.gain.org	Focused on climate adaptation and preparedness hence relevant for resilience Also includes a number of indicators that focus on social vulnerability (ND-GAIN, 2013)	Indicators organized in two categories: (i) Vulnerability: - Food - Water - Health - Ecosystem services - Human habitat - Infrastructure (ii) Readiness: - Economic readiness - Governance readiness - Social readiness	177	2012 (most recent)
Sustainability Index (SI) by Foundation Eni Enrico Mattei (FEEM) http://www.feemsi.org	Measures sustainability of current and future economic activities (up to 2030) Interrelated nature of different aspects modelled through general equilibrium model that takes into consideration	Structured around 3 dimensions of sustainability (i) Economic - Growth drivers - GDP - Exposure (ii) Environmental	40 (with additional countries represented in regions)	From 2007, with projections up to 2030

Index	IGG Relevance	Structure	Coverage	Year(s)
	the indicators within the index Reflects aspects relevant to both natural asset, resource efficiency and inclusiveness themes (Eboli, 2011)	- Pressure - Natural environment - Energy and resources (iii) Society - Vulnerability - Transparency - Well-being		
Environmental Vulnerability Index (EVI) by South Pacific Applied Geoscience Commission http://gsd.spc.int/index.php/environmental-vulnerability-index	Measures the vulnerability of the natural environment to degradation by reflecting hazards, resistance and damage Designed to be used alongside indices of social and economic vulnerability towards a goal of sustainable development Treats the natural environment as a source of resources and services (relevant to natural assets) and an absorber of impacts (relevant to resilience) (SOPAC, 2005)	Utilizes 50 smart indicator organized in 7 themes: (i) Climate Change (ii) Biodiversity (iii) Water (iv) Agriculture and fisheries (v) Human health aspects (vi) Desertification (vii) Exposure to natural disasters	235	2004
OECD Better Life Index (YBLI) (OECD, 2013) http://www.oecdbetterlifeindex.org	Focused on well-being as measured by a set of primarily social dimensions Social indicators do not take account for differences between groups so	Covers 11 dimensions: (i) Housing (ii) Income (iii) Jobs	34 (OECD)	2013 (most recent)

Index	IGG Relevance	Structure	Coverage	Year(s)
	limited relevance for inclusiveness theme Reflects social responsiveness and adaptation capacity with relevance for resilience Includes water quality and air pollution with relevance for the natural assets theme	(iv) Community (v) Education (vi) Environment (vii) Civic Engagement (viii) Health (ix) Life Satisfaction (x) Safety (xi) Work-Life Balance		
Ocean Health Index (OHI) By Conservation International (Halpern et al., 2012) http://www.oceanhealthindex.org	Evaluates the conditions of the marine ecosystems according to ten goals representing different types of benefits provided by healthy oceans Measures the degree to which the current benefit levels do not compromise the ocean's ability to deliver these benefits in the future by measuring the maximum sustainable benefits Combines economic, social and environmental benefits of one key natural asset for many countries Provides a forward-looking metric, which is able to depict the dynamic nature of an IGG	Evaluates present status pressure and resilience for 10 areas: (i) Artisanal fishing (ii) Biodiversity (iii) Coastal protection (iv) Carbon storage (v) Clean waters (vi) Food provision (vii) Coastal livelihoods (viii) Natural products (ix) Sense of place (x) Tourism & recreation	All countries and territories with ocean access	Since 2012, up-dated every year

Index	IGG Relevance	Structure	Coverage	Year(s)
Happy Planet Index (HPI) by The New Economic Foundation http://www.happyplanetindex.org	Measures the extent to which countries deliver long, happy, sustainable lives for their people Includes the ecological footprint as an indicator for environmental sustainability Is also relevant to IGG through its joint consideration of economic, social and environmental aspects	Based on 3 indicators: (i) Life expectancy (ii) Subjective well-being (iii) Ecological footprint	151 countries (in 2012)	2006, 2009, 2012
Climate Change Performance Index (CCPI) by Germanwatch (Burck et al., 2015) https://germanwatch.org/en/9472	Measures country performance on climate change mitigation Only covers climate dimension of IGG Sub-indicators relevant for efficiency, and economic opportunities and efforts theme	Includes indicators measuring: (i) Emissions levels and trends (ii) Renewable energy (iii) Efficiency (iv) Policies	58 countries	2008-2015
Aqueduct Water Risk Atlas by the World Resources Institute http://www.wri.org/our-work/project/aqueduct	- Measures water stress based on stress level at basin-level - Narrow focus on water dimension of IGG - Relevance to natural assets, resource efficiency and resilience theme	Includes sub-indicators in 3 categories: (i) Quantity risk (stress, vulnerability and storage) (ii) Quality risk (return flows and protected land) (iii) Regulatory/ reputational risk (media coverage, water access	Global aggregate coverage (underlying data coverage varies)	2013 (projection for 2025, 2050, 2095)

Index	IGG Relevance	Structure	Coverage	Year(s)
		and threatened amphibians)		
Index For Risk Management by the EU Joint Research Centre (INFORM) http://www.inform-index.org	Evaluates the risk of humanitarian crises that may require international assistance Relevant to the resilience theme through its evaluation of climate vulnerability Some relevance to the inclusiveness theme through vulnerable groups measures	Includes sub-indicators along 3 dimensions: (i) Hazards & exposure (ii) Vulnerability (iii) Lack of coping capacity	189 countries	2014 status and change 2011-2015
Earth Security Index by the Earth Security Group http://earthsecurity.org/earth-security-index	Measures security risks with focus issues for coordinated international action Contains indicators as broad as unemployment, education, rule of law and food scarcity Relevant for natural assets and resilience Includes 7 blueprints for strategic action for resilience	Covers various themes: (i) Population (ii) Governance (iii) Energy (iv) Fiscal (v) Water (vi)Climate (vii) Land (viii) Food	24 countries	2014, 2015

Country-specific and regional indices can be tailored to specific IGG priorities and can also inform policymaking at the subnational level. They can also help governments prioritize policy areas within the country for intervention. Such indices, however, require institutional frameworks and capacities to guarantee coordinated and regular data collection analysis at the subnational level. A few country-

specific indices exist with relevance for IGG measurement, although these vary in their policymaking role:

- **China's Resource and Environment Performance Index (REPI): The** Chinese Academy of Sciences developed the REPI, which combines data on industrial resource use and pollutant generation with measures of GDP in order to compare China with other economies in the region. It has been asserted that the concept of a "Resource Efficient and Environment Friendly Society", first integrated in the 11th Five Year Plan for National Economic and Social Development (2006-2010), was a response of the Chinese Government to its performance in the REPI.[11]
- **The China Green Development Index (CGDI):** Beijing Normal University developed the CGDI during China's development of its 12th Five Year Plan for National Economic and Social Development (2011-15), which stresses green development. The index was initially launched in 2010 and has become an annual report series. Initially, data were available for 30 provinces. By 2013, coverage had expanded to include100 large and medium-sized cities. The index includes over 60 indicators with a focus on three areas: the greening of economic growth (indicators of resource efficiency), carrying capacity potential of natural resources and environment (indicators of resource and ecological conservation, environmental pressure and climate change), and the level of support of government policies (indicators of green investment, infrastructure, and environmental management) (Li & Pan, 2013).
- **Malaysia's Environmental Protection Index:** As a subnational version of the global EPI, this index was developed by the Ministry of Natural Resources and Environment (NRE) and the Universiti Teknologi Malaysia (UTM). First released in 2013, it provides a comprehensive reporting approach on progress on environmental protection. The index complements the Environmental Qualities Indicators (EQI), previously launched by the country, which includes an air pollution and river water quality index. The index development process brought together various government agencies working on different environmental issues.[12]
- **Basque Country Environmental Performance Index (BCEPI):** The Government's Department for the Environment and Territorial Policy of the Basque region in Spain released the BCEPI in 2013. After reviewing several other measurement approaches, including the Ecological Footprint and Natural Capital Accounting, analysts of the Basque Country decided that the EPI framework would be most in alignment with its goal of measuring environmental performance. Interestingly, the index is used not to compare performance of cities or provinces within the country, but to rank the Basque Country among other nations.[13]
- **Bhutan's Gross National Happiness Index (GNH):** This index is a good example of a survey-based index that is well integrated into national policy processes. It was developed with the intention of creating an alternative framework for development that measures the happiness and well-being of the population (Ura, Akire, & Zangmo, 2012). The index is based on surveys conducted in 20 Bhutanese districts covering 124 variables and covers nine themes, including ecological diversity and resilience. The survey-based nature of the index allows a disaggregation and analysis of results by demographic groups. A Gross National Happiness Commission has been established to "ensure that GNH is mainstreamed into the planning, policy making and implementation process" (Gross National Happiness Commission, 2014).

[11] http://epi.yale.edu/indicators-in-practice/chinas-resource-and-environment-performance-index
[12] http://epi.yale.edu/indicators-in-practice/malaysias-environmental-performance-index-0
[13] http://epi.yale.edu/indicators-in-practice/basque-countrys-environmental-performance-index

3.1.3 Footprint

Various footprint indicators have been developed that typically measure global and national consumption. A few selected examples include:

- **Ecological footprint:** This metric measures how much of the biosphere is used by human activities compared to its biophysical and regenerative capacity. It compares the amount of land and water area needed to support the existing population at its current level of consumption, including energy, food and fiber, timber and paper. The Ecological Footprint is calculated by the Global Footprint Network for over 170 countries each year and is published in WWF's Living Planet Report. It has gained increasing popularity by NGOs and is often used to raise public awareness and integrate ecological limits into decision-making.[14]
- **Resource footprint of nations:** Using the latest version of EXIOBASE (a detailed multi-regional, environmentally extended supply and use/ input output database), Tukker et al. (2014) endeavor to provide an insight into the environmental footprint of final consumption in 43 countries. It presents a cross-country comparison as well as 43 country factsheets encapsulating the carbon, water, land and material footprint of final consumption in the countries covered by EXIOBASE.
- **Carbon footprint:** Eurostat provides an estimate of carbon dioxide (CO2) emissions induced by the final use of products, using modelling-estimations based on various European Union (EU) datasets, extended supply use and input–output tables. These integrated data can be used to inform environmental and macro-economic policies.[15] Similarly, OECD measures carbon embodied in international trade for a large set of countries (OECD, 2015a).
- **Raw material consumption (RMC):** Eurostat extends the material flow accounts framework by estimating the material footprint of the goods consumed (i.e. the total amount of raw materials needed to produce them) in the member States of the European Union (EU). The inputs of materials to European economies are systematically recorded, breaking them down by material category, such as fossil energy materials, biomass and metal ores, among others. For compiling material consumption estimates at the country level, Eurostat has a country tool, handbooks and input datasets.[16]
- **Water footprint:** A scientific study estimates the water footprint of national production/ consumption based on spatial data for rainwater, fresh and surface water and water pollution (Hoekstra & Mekonnen, 2012). The study follows the Global Water Footprint Standard developed by the Water Footprint Network to provide comparable estimates that follow the consistent definitions, approaches and methods (Hoekstra, Chapagain, Aldaya & Mekonnen, 2011). Footprint assessments can be produced for various countries and products.[17]

While these global footprints have garnered increased public attention, national-level applications to inform policymaking are rare:

- **Switzerland's Environmental Impact of Consumption and Production:** The Swiss Federal Office for the Environment calculates thematic indicators for GHG emissions (carbon footprint), water use, air pollution, land use (influence on biodiversity), nitrogen (eutrophication) and primary energy consumption (Frischknecht et al., 2014, based on Frischknecht et al., 2013 and Jungbluth, Nathani, Stucki & Leuenberger , 2011). Environmental

[14] http://www.footprintnetwork.org/en/index.php/GFN/
[15] http://ec.europa.eu/eurostat/statistics-explained/index.php/Carbon_dioxide_emissions_from_final_use_of_products
[16] http://ec.europa.eu/eurostat/statistics-explained/index.php/Material_flow_accounts_-_flows_in_raw_material_equivalents#Material_flow_indicators_in_RME
[17] http://waterfootprint.org/en/water-footprint/

impacts are calculated for various categories of goods using data from official statistics on domestic emissions and consumption of resources, as well as foreign trade statistics and life cycle assessment (LCA) data. Along with these footprint indicators for specific environmental aspects an indicator for the total environmental impact of consumption and production is published. A single metric is generated from various environmental impacts (e.g. climate change, use of different land types, emissions of pollutants in air, water and soil) by using the method of ecological scarcity, which is frequently used in environmental impact assessments. The method was updated in 2013. It is based on Swiss targets or international targets agreed to by Switzerland (see Frischknecht et al., 2014).

- **Scotland's Ecological Footprint:** In 2004 Scotland completed a footprint exercise, analyzing resource and waste flows in the Scottish economy (Chambers et al., 2004). In 2007 the Government of Scotland adopted the Global Footprint Network's Ecological Footprint as one of the indicators for its 2006 National Performance Framework to measure progress in reducing GHG emissions and the impact of consumption and production.[18]
- **Ecological Footprint in Arabic States:** The Arab Forum for Environment and Development (AFED) commissioned a 2012 Global Footprint Network analysis for member States of the Arab League. AFED has used the findings to develop a set of alternative development strategies organized around the themes of food security, water and energy (Tolba & Saab, 2012).

3.1.4 Adjusted economic measures

Adjusted GDP measures can help policymakers understand the wide range of impacts of national policies – including at subnational levels (Posner & Costanza, 2011). There are two notable global indicators of adjusted GDP:

- **The Index of Sustainable Economic Welfare (ISEW):** This index provides an estimate of total private and public wealth, including natural resources. It mediates some of the shortcomings of GDP by subtracting elements from consumption measures that do not positively contribute to welfare (e.g. defensive expenditure) and by adding monetary estimates for those that do (e.g. unpaid time for domestic work). It further accounts for the formation and depreciation of reproducible and non-reproducible capital (limited to land and net foreign assets), educational capital (based on the cumulated cost of years spent into education by people belonging to the labour force) and health capital (based on a method of permanent inventory). And it does so before adjusting for the depletion of non-renewable natural resources and the costs of environmental degradation – mainly the costs of water, air and noise pollution, and losses of wetlands, farmland, primary forests and CO2 damages, and ozone depletion. ISEW was first published for the US, covering the period from 1950 to 1986 (Daly & Cobb, 1989). Updates and variations of the ISEW have been calculated for some other countries (see table 8).
- **The Genuine Progress Indicator (GPI):** is a variant of the ISEW that uses a refined methodology, including updated data sources. Interestingly, it discounts personal consumption by income inequality to account for income distribution. The inequality weighted personal consumption is adjusted for the value of welfare increasing activities (e.g. household work, parenting, volunteer work, higher education and public road maintenance) and the costs of welfare-reducing activities (e.g. costs of crime, commuting, car accidents and consumer durables of household pollution abatement). As in the ISEW, the depletion of non-renewable natural resources and costs of environmental degradation are included. Global data have been published for 1950-2004 (Talberth et al., 2007).

[18] http://www.gov.scot/About/Performance/scotPerforms/indicators/ecologicalFootprint

Although GPI and ISEW estimates are available at both the national and subnational levels for a number of countries (see table 8), so far their role in national policymaking has been limited. Most of the existing estimates come from one-off studies used for advocacy or academic purposes and do not always follow exactly the same methodology. Kubiszewski et al. (2013) provide comparable estimates for 17 countries between 1950 and 2010. The huge data needs for regular updates are one reason for their limited policy applications. Yet with improved data availability, updating these metrics would likely become less costly.

Recently the US state governments of Maryland and Vermont have adopted GPI as an official indicator. Maryland chose the GPI for its proven track-record, fine-tuned the GPI methodology and improved the data to meet particular needs. Based on this effort, a new measurement tool was created that allows policymakers to compare how in one subcomponent investments and decisions are affected by other indicators.[19]

Table 8. Studies estimating ISEW or GPI at national or subnational level

Country	Time	Study
National level		
Australia	1950–1996	Hamilton, 1999
	1950–2000	Hamilton & Deniss, 2000
	1967–2006	Lawn, 2008a
Austria	1955–1992	Stockhammer, Hochreiter, Obermayr & Steiner, 1997
Belgium	1970–2000	Bleys, 2006; 2008
Chile	1965–1995	Castaneda, 1999
China	1970–2005	Wen, Zhang, Du, Li, & Li, 2008; Zhang, Wen, Du, & Song, 2008
	1978–2007	Jin & Hunter, 2013
Czech Republic		Scasny, 2002
France	1990–2002	Nourry, 2008
Germany	1950–1990	Diefenbacher, 1994
India	1987–2003	Lawn, 2008b
Italy	1960–1991	Guenno & Tiezzi, 1998
	1999-2009	Gigliarano, Balducci, Ciommi & Chelli, 2014

[19] http://www.dnr.maryland.gov/mdgpi/bandm.asp

Japan	1970–2003	Makino, 2008
Netherlands	1950–1992	Oegema & Rosenberg, 1995
	1971–2004	Bleys, 2007
New Zealand	1970–2005	Forgie, McDonald, Zhang, Patterson, & Hardy, 2008
	1970–2006	Forgie & McDonald, 2013
Madagascar	1980–2004	Ollivier & Giraud, 2010
Poland	1980–1997	Gil & Sleszynski, 2003
Portugal	1960–2010	Beça & Santos, 2014
Scotland	1980–1993	Hanley, 1999
Republic of Korea	1970–2005	Feeny, Mitchell, Tran & Clarke, 2013
Sweden	1950–1992	Jackson & Stymne, 1996
Spain		Cabello, Navarro, Prieto & Rodriguez, 2014
Thailand	1975–1999	Clarke & Islam, 2005
	1975–2004	Clarke & Shaw, 2008
UK	1950–1996	Jackson, Marks, Ralls, & Strymne 1997
US	1950–2004	Talberth, et al. 2007
	1950–2005	Beça & Santos, 2010
	1960–2010	Beça & Santos, 2014
Russian Federation	1985–2008	Shmelev, 2011
Viet Nam	1992–2004	Hong, Clarke & Lawn, 2008
Wales	1990–2000	Matthews, Munday, Roberts & Williams, 2003
Viet Nam	1992-2004	Hong et al., 2008
Wales	1990-2000	Matthews et al., 2003
Subnational level		
Australia	State of Victoria	Lawn & Clarke, 2006
Belgium	Flanders	Bleys, 2013

Canada	Province of Alberta	Anielski, 2001; Taylor, 2005
	Province of British Colombia	Gustavson & Lonergan, 1994
	Province of Nova Scotia	Pannozzo et al., 2008
	City of Edmonton	Anielski & Johannes, 2009
China	Cities of Suzhou, Yangzhou, Ningbo and Guangzhou	Wen et al, 2008
England	All English regions	Jackson, Mc Bride, Abdallah & Marks , 2008
Finland	Regions of Päijät, Häme and Kainuu	Hoffren, 2011
Italy	Province of Siena, Modena, Rimini, Tuscany	Pulselli, Ciampalini, Tiezzi, & Zappia , 2006; Pulselli, Tiezzi, Marchettini, & Bastiononi, 2008; Pulselli, Bravi, & Tiezzi, 2009; Pulselli, Bravi, & Tiezzi, 2012
New Zealand	Wellington	Packard & Chapman, 2012
US	7 northeast Vermont counties, state of Vermont	Bagstad & Ceroni, 2007; Erickson, Zencey, Burke, Carlson & Zimmerman ., 2013
	Cities of Akron and Cleveland, 17 northeast Ohio counties, State of Ohio	Bagstad & Shammin, 2009; 2012
	City of San Francisco, 8 California counties	Redefining Progress, 2006
	City of Burlington, Chittenden County, State of Vermont	Costanza et al., 2004
	City of Baltimore, Baltimore County, State of Maryland	Posner, 2010
	State of Maryland	Posner & Costanza, 2011; McGuire, Posner & Haake , 2012
	State of Minnesota	Minnesota Planning Agency, 2000
	State of Utah	Berik & Gaddis, 2011

	Hawaii	Hawaii Department of Health, 2013; Ostergaard-Klem & Oleson, 2014

There have also been efforts to measure adjusted net savings and extended wealth for a large number of countries:

- **Adjusted net (genuine) savings and total wealth:** Produced by the World Bank, adjusted net-savings provides a comprehensive metric for measuring changes in financial, physical, human and natural capital. It is derived from the measures of gross national savings in the System of National Accounts (SNA) by making four types of adjustments: (i) depreciation of physical capital measured by capital consumption of produced assets; (ii) human capital formation measured by current expenditures on education; (iii) depletion of natural resources, including energy, minerals, and forest resources; and (iv) environmental damages through particulate matter (PM) air pollution and CO2 emissions (Hamilton & Clemens, 1999). To date, it is notably the most comprehensive effort to calculate changes in extended wealth, and it covers more than 130 countries, including around 100 developing countries. The metric is updated annually and reaches back to 1970, providing a rich time series of data. Several data limitations are to be noted, particularly, the limited set of environmental impacts being considered. Work is ongoing to improve the various components. Nevertheless, the data have been entry points for country dialogue on the management of natural resources, and the metric is used for the World Bank's systematic country diagnostics to identify sustainability constraints.
- **Comprehensive wealth:** Complementary to the adjusted net-savings data, the World Bank measures countries' total wealth stock, including produced capital and natural capital, comprising subsoil assets, agricultural land, forest land and protected areas (World Bank, 2006, 2011). This indicator is also available for 1995, 2000, 2005, 2008 and 2010. Using adjusted net-savings data and accounting for wealth-diluting effects of population growth, the changes in wealth per capita can be calculated. This measure has recently been introduced in the measurement framework of the World Bank Group, such as the corporate scorecard.[20]
- **Inclusive wealth:** The United Nations University-International Human Dimensions Programme (UNU-IHDP) and UNEP have published the Inclusive Wealth Report (IWR) with extended wealth measures as the sum of the social values of an economy's capital assets, including manufactured capital, human capital and natural capital. Inclusive wealth was first measured in 2012 for approximately 20 countries. The latest publication for 2014 contains data for 140 countries (UNU-IHDP & UNEP, 2014). Whereas the approach and concepts are similar to those used by the World Bank in its comprehensive wealth measure, UNEP used refined data and methods for the different capital components. Consequently the wealth estimates cannot be readily compared.

An increasing number of countries seek to integrate environmental and economic statistics into the SNA. A major step in this direction was achieved in 2012 with the adoption of the System for Environmental-Economic Accounts (SEEA) by the United Nations Statistical Commission. The SEEA Central Framework (CF) provides an international standard – including agreed concepts, definitions, classifications, and accounting rules – for the valuation (in physical and monetary terms) of environmental assets and environmental depletion costs (UN Stats, 2014a). The SEEA CF uses the same accounting conventions as the SNA to measure the physical and monetary flows of natural inputs, products and residuals. It considers assets from the perspective of individual assets, such as land, renewable (e.g. timber) and non-renewable resources (e.g. minerals).

[20] http://www.worldbank.org/en/about/results/corporatescorecard

The SEEA has been complemented by two additional parts that are not statistical standards: (1) SEEA Experimental Ecosystem Accounts, which provides a consistent summary of approaches that considers environmental assets from a system perspective and recognizes a broader set of services from these ecosystem assets (UN Stats, 2014b); and (2) the SEEA Extensions and Applications, which presents a more detailed description of ways to compile accounts and to inform policy analysis (UN Stats, 2014c). In addition, subsystems of the SEEA framework are being developed for specific themes, including, energy, water, land, ecosystems and agriculture, and forestry and fisheries, which are fully consistent with the SEEA but provide more detailed guidance.

Expanding national accounting frameworks to include information on natural capital is a promising means to better IGG measurement. If done right, augmenting SNA metrics to reflect natural resource use and depletion and environmental degradation can reveal the environmental sustainability of current economic production. Natural capital accounting can also produce additional indicators, such as environmental expenditure or environmental degradation costs, demonstrating the values of ecosystems and the services they provide, which can inform IGG measurement.

Yet compiling natural capital accounts requires substantial data and the technical expertise to analyze such data. Many countries lack the financial resources and technical capacities for data collection and analysis, and also the institutional frameworks to implement such accounts. Global partnerships, such as the OECD Taskforce on the implementation if the SEEA, The Economics and Ecosystems and Biodiversity (TEEB) initiative, and the World Bank's Wealth Accounting and the Valuation of Ecosystem Services (WAVES) are supporting countries implementation of natural capital accounts (see box 1). Similarly, academic initiatives, such as the Natural Capital Project, seek to integrate ecosystem values into economic decision-making.[21]

Box 1. Wealth Accounting and the Valuation of Ecosystem Services (WAVES)

WAVES is a global partnership that aims to mainstream natural capital into development planning and national economic accounts. This global partnership brings together a broad coalition of United Nations agencies, governments, international institutes, nongovernmental organizations and academics to implement Natural Capital Accounting (NCA). Countries are supported to implement NCA where there are internationally agreed standards that follow the SEEA CF and to develop experimental accounts for ecosystems, such as watersheds and mangroves. Recently, Guatemala, Indonesia and Rwanda joined WAVES as core implementing countries. The initial core implementing countries, Botswana, Colombia, Costa Rica, Madagascar, and the Philippines have already established national steering committees, carried out stakeholder consultations, identified policy priorities and designed work plans that are now being implemented.

- **Botswana** plans to implement accounts for water, land and ecosystems, and mineral and energy resources. Work on water accounts has resulted in a policy focus on water-use efficiency (including demand management and integrated water-use management) as well as water allocation (maintaining supply to the highest value-added sectors without neglecting basic needs or ecological water needs) (WAVES, 2014).
- **Colombia** has previous experience implementing accounts for energy and mineral resources and environmental protection expenditure. The work of WAVES is centred on the importance of watersheds in providing ecosystem services. A pilot program that includes water (withdrawal and use) and forest accounts (based on REDD+ work) has been

[21] http://www.naturalcapitalproject.org/about.html

completed in three watersheds, and there are plans to expand WAVES work to national level accounts (WAVES 2014b).
- **Costa Rica's** water accounts take a slightly different angle, focusing on pollution and its costs, while the country's forest accounts focus on timber and non-timber forest products (WAVES 2014b).
- **Madagascar** is exploring the feasibility of implementing protected areas/ tourism accounts that reflect the large value generated by the country's biodiversity (WAVES 2014b).
- **The Philippines** is preparing mangrove accounts that will record the impact of these resources on local incomes as well as climate resilience (WAVES 2014a).

Source: http://www.wavespartnership.org/en/about-us

While the number of countries experimenting with particular aspects of natural capital accounting is growing, a more comprehensive coverage of aspects related to natural resource depletion and environmental degradation will be needed. Such comprehensive natural capital accounts have only been implemented by a small number of countries, such as Germany, Iceland, Ireland, Italy, Netherlands, New Zealand, Norway, Republic of Korea, Sweden, and the United Kingdom (see table 6). Other countries have focused on particular themes most relevant to their specific country context (see table 9). For instance, natural resource rich countries, such as Botswana, Guatemala, and Namibia have prepared accounts for minerals, fisheries and forest, while countries with polluting industries, such as in Eastern Europe, have mainly implemented accounts for air quality.

Table 9. Examples of specialized natural capital accounts

Application	Country	Year
Air	Slovenia	2006
	Czech Republic	2005
	Hungary	2005
	Greece	2001
	Spain	2001
Fisheries	Guatemala	2009
	Namibia	2006
	Philippines	2000
Land, soils, forests	Botswana	2013
	Guatemala	2009
	Spain	2007
	Estonia	2005
	Zimbabwe	2002

	India	2000
	Philippines	1998
Minerals	Botswana	2013
	India	2007
	Namibia	2006
	USA	1994
Water	Botswana	2013
	Mexico	2011
	Namibia	2006
	Morocco	2005
	Greece	2002
	Spain	2002

3.2 Indicators for the IGG measurement themes

Regardless of the measurement approach chosen, a number of different indicators will be needed to cover the five measurement themes proposed in this paper. Indicators will naturally vary by quality, coverage and data availability. Given this, the selection of indicators should be evaluated against the following criteria: data quality and availability, analytical soundness and methodological transparency, policy relevance, and ease of communication and interpretation (OECD, 2011b).

Optimally, the underlying data should also allow analysis at different levels of detail or aggregation, as tracking particular issues may be more relevant at the subnational level. For example, a national annual average of air quality may be of limited value, while the share of population exposed to hazardous levels of air pollution may be much more telling. Similarly, aggregate CO2 productivity may mask a very fuel intensive transport sector combined with an energy sector that relies heavily on hydro or nuclear. Hence, the possibility of disaggregation by groups, sectors or regions within a country will increase the usefulness of the indicators.

Global databases and initiatives can provide inputs into cross-country comparisons and IGG decision-making. The following provides a summary of the main conclusions drawn from a review of relevant global data sources for the five IGG measurement themes (see Appendix A1-A5 to the present document):

- **Natural assets:** A great variety of data tracks the current status and changes over time of natural resources with limited reflection of qualitative aspects and accessibility of some of the resources, while data on economic costs and benefits and optimal or sustainable use is rare.
- **Resource efficiency and decoupling: Production**-based resource efficiency indicators depend on data availability for both the resource and the economic production dimension, which is generally good at the national level but less so at lower levels of aggregation. Demand-side data are, however, particularly difficult to obtain.

- **Risk and resilience:** Although several data sources exist that measure particular aspects of economic resilience and ecological risks or the ecological risks themselves, truly comprehensive approaches and metrics that capture this multidimensional concept are missing.
- **Economic opportunities and efforts:** Meaningful, ready to-use indicators of economic opportunities and efforts are scarce, which is often linked to challenges associated with identifying, defining and measuring opportunities. Indicators tracking environmental policies remain an underdeveloped area, with relatively poor data coverage of existing indicators.
- **Inclusiveness:** There is a notable lack of data sources and indicators that capture the social dimensions of green growth and the distribution of costs and benefits of environmental policies among different societal groups.

3.2.1 Natural assets

A great variety of data related to biophysical aspects of natural assets are available with nearly global coverage (see table A1). Various coordinated efforts have been undertaken by the United Nations to produce official data – mostly collected and reported by countries – on the status of land and water resources, as well as pollution and GHG emissions. In addition, new studies have produced global data on forest cover, land degradation and air pollution, making use of new technologies, such as remote sensing data (e.g. Hansen et al., 2013; Bao Le, Nkonya, & Mirzabaev, 2014; Brauer et al., 2015). And international initiatives and agencies have created databases to facilitate data access and analysis, most notably the World Resource Institute (e.g. through Global Forest Watch, Aqueduct and Climate Data Explorer). Also, the World Bank provides open access to environmental indicators in the World Development Indicators and summarizes relevant data at the regional and country levels in the Little Green Data Book (World Bank, 2014). A selection of relevant data has also been made available through the Green Growth Indicators of the OECD.[22] Web-based tools that provide easy access to spatial data also become increasingly available, such as UNEP Live.[23]

Most of these environmental data sources provide insights into the current status and changes over time of resources, but they do not reflect qualitative aspects, the scarcity of these resources or future threats. For example, existing water statistics focus on the quantitative availability of water resources, sometimes accounting for spatial and inter-annual variation (e.g. WRI Aqueduct). Yet they rarely do account for water quality, and do not evaluate water resources against thresholds beyond which water supply becomes scarce or water demand becomes unsustainable. For many renewable resources, considering thresholds is critical, as tipping points exist beyond which the changes are irreversible (e.g. if fish stocks decline below a certain level it is difficult, if not impossible, for them to recover). Similarly, information on natural resource stocks does not usually take into account the accessibility of such resources. In other words, the sources of data do not discriminate between stocks that may be easy to access and stocks that may be extremely costly to extract using existing technologies. Similarly, they tend to focus on “primary” asset bases (e.g. subsoil minerals) rather than stock embedded in produced goods, which may be recycled at differing costs.

Moreover, many of the environmental indicators do not reflect economic aspects, such as optimal (or sustainable) levels of withdrawals or the economic costs/ benefits of resource depletion. One of the few exceptions is the World Bank’s data on adjusted net-savings, which includes country-level values for natural resource depletion and the costs of pollution and emissions, as well as the value of subsoil assets, agricultural land, forest land and protected areas. However, these estimates also face certain

[22] http://stats.oecd.org/Index.aspx?DataSetCode=GREEN_GROWTH
[23] http://uneplive.unep.org/

limitations with regard to the valuation techniques applied, and values are generally highly uncertain with regard to the prices and discount rates applied.

TEEB initiative has started the implementation of case studies for the valuation of ecosystem services in a number of different countries, which will provide further insights into the values of natural assets at a national level. Full reports have been prepared for Germany, the Netherlands, Norway, and the United Kingdom. In addition, baseline studies have been conducted for Slovakia and South Africa, and scoping studies have been conducted in Georgia, India and the ASEAN countries. Five additional countries are implementing TEEB country studies: Bhutan, Ecuador, Liberia, the Philippines and the United Republic of Tanzania. In addition, TEEB-relevant case studies have been identified for a longer list of countries. Additional databases exist that give an overview of existing ecosystem valuation studies, such as TEEB Ecosystem Valuation Database (ESV)[24] and the Environmental Valuation Reference Inventory (EVRI).[25] Yet these initiatives do not follow a systematic approach to estimate a country's natural assets in a comprehensive and comparable way.

3.2.2 Resource efficiency and decoupling

Resource efficiency indicators combine resource, energy use, emissions waste production or footprint data with economic output data, such as value added or production volumes or final demand (table A2). Given this, the availability of resource efficiency data is driven by the availability of data for the underlying components, and is often fairly good at the national level, but less so at the subnational level.

National statistics offices in a number of countries collect data on the aggregated use of selected resources, which can then be combined with widely available economic performance data. OECD, the International Energy Agency (IEA), the European Environment Agency (EEA) and the United Statistics Division (UNSD) provide various efficiency or productivity indicators across countries, though often the coverage for developing countries and over time is poor. Definitional issues tend to pose problems regarding international comparisons (e.g. in waste) even in data where collection is coordinated across countries. In practice, it can often make more sense to compare the developments across the two dimensions than necessarily combine them into one indicator (e.g. looking at GDP developments and emissions, rather than necessarily dividing one by the other). In such cases, national statistics or Eurostat can provide meaningful figures in a number of additional areas.

On the other hand, demand-based indicators and metrics for decoupling can be assessed using data on resource or energy use, emissions, waste production or footprint data. As discussed in section 3.1, there are various initiatives that have produced footprint indicators for a larger set of countries. Metrics showing the resource intensity of consumption are scarce. An example is the OECD's work on embodied carbon, which is calculated for all member States of OECD, G20, EU28 and ASEAN (61 countries in total), and then used to derive the OECD's demand-based CO2 productivity, measured by real income per energy-related CO2 emissions (OECD 2015a). Similar work directed at embodied (non-energy) materials and demand-based material productivity is ongoing.

Finally, recent OECD work provides information on growth in environmentally adjusted multi-factor productivity (EAMFP) (OECD, 2016a). EAMFP aims to measures a country's ability to generate income from a given set of inputs, while accounting for the consumption of natural resources and production of undesirable environmental outputs. The EAMFP has the potential to complement the traditional measure of productivity – multi-factor productivity (MFP) – widely used by economic and finance

[24] http://www.fsd.nl/esp/80763/5/0/50
[25] https://www.evri.ca/Global/Splash.aspx

policymakers, and thus foster greater consideration of environmental concerns in economic policy decisions. By decomposing overall growth in GDP into the contributions of individual factor inputs – labour, produced capital and natural capital – the EAMFP measurement framework allows the sources of growth to be identified more accurately. In some countries, the contribution of natural resource extraction to economic growth is rather high and this might raise concerns over the expected future growth path of these economies. The indicator measuring the contribution of natural capital to output growth allows prospects for sustaining growth to be assessed when natural capital becomes scarce.

3.2.3 Risks and resilience

Several data sources exist that measure certain aspects of economic resilience to ecological risks (see table A.3). However, a variety of indicators from different data sources would be needed to comprehensively cover the various aspects of resilience, including ex-ante dimensions of risk reduction and ex-post dimensions of recovery and reconstruction. One challenge is also related to measuring resilience for different ecological risks – ranging from acute environmental pollution and degradation and short-lived extreme events (such as floods, droughts and wild fires) to gradual climatic changes.

Most indicators related to resilience are based on historic data measuring the fatalities and economic damages of events in the past, such as through the International Disaster Database, compiled by the Centre for Research on the Epidemiology of Disasters (CRED). At the same time, countries are developing national disaster-loss databases with help from the United Nations Office for Disaster Risk Reduction. Yet such data can only bring limited insights into the potential impacts of future events, as the occurrence of past events may not represent risks in the future, especially under climate change. Thus, the potential impacts of future risks should be modelled in order to improve insights. Relevant, easy-to-use, up-to-date data at the global level is, however, rare.

In any event, the use of such impact data – either monitored based on historic data or modelled – does not distinguish between impacts due to inherent conditions (i.e. being in a hazard-prone location) from impacts due to insufficient policies or institutions. For example, a small-island developing State in a hurricane corridor may suffer disproportionately regardless of the resilience of its economy.

Risks can be measured through data on exposure or vulnerability. One example to measure environmental risks is the Global Burden of Disease study, which publishes country-level data on the major causes of diseases and their impacts on life expectancy – listed by different risk factors, including indoor and outdoor air pollution.[26] The latest publication includes data from 1990 until 2013 and further updates are planned. The study has calculated the disease burdens attributable to exposure to PM2.5 air pollution (Brauer et al., 2015). Based on these data, estimates of the population share exposed to harmful air pollution levels can be calculated.[27]

While improved data on natural hazards, such as the Aqueduct Global Flood Maps,[28] can help to measure people and assets exposed to climate and disaster risks, data measuring their vulnerability or resilience is limited. Most data would provide proxies for resilience, such as the coverage of social protection from the World Bank's Atlas of Social Protection Indicators of Resilience and Equity (ASPIRE), financial savings and risks management of people from the World Bank's Global Financial

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[26] http://www.healthdata.org/results/country-profiles
[27] http://www.worldbank.org/en/news/feature/2015/07/14/understanding-air-pollution-and-the-way-it-is-measured, OECD (2016b).
[28] http://www.wri.org/resources/data-sets/aqueduct-global-flood-risk-maps

Inclusion (FINDEX)[29] database or housing quality from the Prompt Assessment of Global Earthquakes for Response (PAGER).[30]

Efforts are also growing to measure the government capacity to respond and adapt to climate and disaster risks. Often these data do not differentiate between policies on the book (de jure policies) and those that are actually enforced and effectively implemented (de facto policies). For instance, the Hyogo Framework for Action 2005-2015 (HFA) includes a comprehensive monitoring system, through which countries self-report the progress they make to reduce disaster risk reduction. The Inter-American Development Bank has developed several indicators to measure a government's capacity to manage disaster risks, such as the Disaster Deficit Index and the Risk Management Index Government.

Actual enforcement of disaster risk reduction policies is also being increasingly measured. Currently, the monitoring system for the Sendai Framework for Disaster Risk Reduction 2015-2030, the successor arrangement of HFA, is being discussed, which is supposed to revise the 22 existing HFA core indicators and link input indicators to outputs and outcomes. Seven global targets for disaster risk reduction were agreed upon to guide indicator development (WCDRR, 2015). Additionally, the Inter-American Development Bank has developed the index of Governance and Public Policy for DRM (iGOPP) based on 246 questions to assess the enforcement of actual polices, which has been applied for six Latin American countries (IDB, 2014). As part of the World Bank's World Development Report 2014, an indicator of risk preparedness was developed, which comprises measures of assets and services across four categories: human capital, physical and financial assets, social support, and state support (World Bank, 2013).

Global composite indices have been constructed to measure the various dimensions of resilience and adaptive capacity at the country-level, such as the Notre Dame Global Adaptation Index (ND-GAIN) and the EU JCR Index for Risk Management (INFORM) (see table 7). The ND-GAIN measures a variety of aspects related to a country's vulnerability to and readiness for climate risks.[31] INFORM measures aspects related to exposure and vulnerability to hazards and coping capacity.[32] Yet both these indices are constrained by global data availability, and many important aspects of resilience, such as social protection and ability to reconstruct are not reflected. The World Bank is developing a new indicator to estimate the welfare losses of potential disasters based on a simple economic model.

3.2.4 Economic opportunities and efforts

Meaningful, ready-to-use indicators of economic opportunities and efforts are rare (see table A3). Data related to investments and trade often exist, but are difficult to access or use. Most of the information on investments is in the private domain and not publically available at a disaggregated level. Trade databases exist, but trade classifications are currently not sufficiently granular to allow the identification of data points related to trade in environmental goods and services, usually because these are problematic to identify. As part of developing the GEP index, UNEP is creating a database of exports of environmental goods using existing datasets.

Measurement of environmental-economic data (investments, patents, R&D, jobs, exports) is usually associated with the performance of the Environmental Goods and Services Sectors (EGSS), as collected, for instance, by Eurostat.[33] However, there is still much uncertainty with respect to the

[29] http://www.worldbank.org/en/programs/globalfindex
[30] http://earthquake.usgs.gov/earthquakes/pager/
[31] http://gain.org/
[32] http://www.inform-index.org/
[33] http://ec.europa.eu/eurostat/statistics-explained/index.php/Environmental_goods_and_services_sector

definition of EGSS and sector classifications, which remain the subject of negotiations in the World Trade Organization (Sauvage, 2014; Steenblik, 2005).

Regarding innovation, the OECD collects and publishes patent numbers based on the Worldwide Patent Statistics Database (PATSTAT) on many inventions relevant for IGG, including clean energy generation and efficiency, transport fuel efficiency, environmental management and emission mitigation. This patent mapping is available for the past three decades with a global coverage (OECD, 2015b).

Indicators measuring various aspects of environmental policies and planning are also patchy. Data on protected areas on land and sea are available for all countries and yearly updated based on data from national authorities, national legislation and international agreements – hence raising some issues of comparability. Through the Biodiversity Finance Initiative, UNDP is working on determining country investment in biodiversity in order to quantify the full cost of meeting national biodiversity conservation targets. Eurostat has published data for environmental protection expenditure, which is only available for 11 countries.

Several well-developed concepts exist regarding specific policy instruments, such as policy support to particular activities (fossil fuel subsidies or renewable energy) and tax instruments. Arguably, the broadest coverage concerns data on fossil fuel subsidies, which are collected and compiled in several ways. The IEA compiles data for many developing countries based on the price-gap method, which compares average end-user fossil fuel prices (and prices of electricity generated from fossil fuels) paid by consumer to reference prices that are constructed to correspond to the full cost of supply. The OECD collects fossil-fuel data related to detailed measures and volumes of support, such as tax expenditures, present in OECD and G20 countries (OECD, 2015c). The IMF also produces estimates of fossil- fuel subsidies, covering 176 countries. Their methodology, labelled "pre-tax subsidies," uses a combination of calculation methods based largely on data from the IEA, OECD and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) (IMF, 2013).[34] In all cases, time series coverage is limited to a handful of recent years. Further examples of data on policies that potentially work against IGG include the OECD inventory of agricultural subsidies, available since the 1980s for most OECD member States.[35]

Environmentally related taxation revenue data are collected by the OECD, primarily for OECD countries, but coverage has been gradually extended to several emerging economies and developing countries (OECD, 2015d). The private consulting firm, KPMG, on the other hand, proposes a composite indicator that ranks 21 major economies based on experts' evaluations of 12 selected aspects of environmentally related taxation, including tax rates, tax expenditures and other incentives from national tax codes.[36] Some data on environmentally related public and private R&D expenditure are also collected by the IEA (for selected member countries, over the past two decades) and by Eurostat.

Regarding broader measures of the stringency or strictness of environmental policies, the World Economic Forum's Executive Opinion Survey compiles questionnaire surveys of managers' perceptions. The survey has global coverage and has been produced over the past decade. The OECD provides composite stringency indicators, which combine information on strictness of some 15 environmental policy instruments into a single proxy. The data are available for the past two decades,

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[34] The IMF's "post-tax subsidies" approach however, adds in IMF's estimates of externalities associated with the combustion of fossil fuels, as well as externalities related to driving vehicles, such as traffic congestion and accidents. These externality costs cover about 88 per cent of the value of their "post-tax subsidies".

[35] http://www.oecd.org/tad/agricultural-policies/producerandconsumersupportestimatesdatabase.htm

[36] http://www.kpmg.com/global/en/issuesandinsights/articlespublications/green-tax/pages/default.aspx

albeit for a subset of 24 OECD countries (Botta & Kozluk, 2014). These are currently being updated and extended to include BRIICS countries.

3.2.5 Inclusiveness

There is hardly any data available with respect to the social dimensions of green growth and the distribution of costs and benefits of environmental policies among different groups of society (see table A5). In some cases, the pathways and channels through which such environmental impacts and green policies affect different groups of society are not well understood. In addition, assessing distributional impacts requires data at the household or individual-level, and the regular collection of such data can be costly.

Although distributional aspects are not explicitly measured, some data have been collected on access to environmental goods and services. Following the adoption of the Millennium Development Goals (MDGs), including targets for access to improved water and sanitation, data for this target have been collected through the WHO/UNICEF Joint Monitoring Program (WHO & UNICEF, 2014). Likewise, a country's share of the population with access to improved electricity is now being regularly updated through the United Nations Sustainable Energy for All (SE4All) tracking framework, which is updated by the World Bank and the IEA (World Bank & IEA, 2014). As often these data originate from household surveys, disaggregation by different household groups is possible, as for example in the International Income Distribution Dataset (I2D2), compiled by a World Bank team.

Where environmental data, on natural assets or environmental risks, is geo-spatial, it could be overlaid with maps showing population and their welfare status providing and inclusive dimension of access to natural resources or exposure to environmental risks. Some studies are trying to provide some insights into the spatial relationships between natural hazards and poverty (Hallegatte, et al. 2016). Yet generally, spatial data disaggregated by social groups is not yet available through global databases.

Data on social inclusion are available but often with little connection to environmental issues. There is some noteworthy data covering women's access to land, including FAO's Gender and Land Rights Database. This information does not, however, allow researchers to assess whether land is used in an environmentally friendly way. The World Bank's Women, Business and the Law database includes a variety of qualitative information with regard to institutions, property and jobs, but none of these are of direct relevance for environmental aspects.

More data are needed to capture the distributional aspects of exposure to environmental dangers, participation in environmental decision-making and the costs/ benefits of green policies. In particular, data on the impacts on poor people, women, and other often less powerful and more vulnerable groups, as well as the resulting changes in livelihoods, employment and incomes are needed to better get a grasp of the inclusiveness of green growth.

4. Measurement gaps

Based on above stocktaking, a number key knowledge gaps have been identified related to IGG measurement approaches. Progress on addressing these gaps can lay the groundwork for sound empirical research to enhance the understanding of IGG processes and outcomes. The list of identified gaps (shown below) is broadly consistent with the gaps and challenges identified in similar analyses (UNEP, 2011; OECD, 2014; GGKP, 2013).

The reasons for these data gaps are multifold, including lack of clear definitions for complex concepts (e.g. resilience), limited understanding of environment-economy-society interactions (e.g. how ecosystem services benefit different people), costs for data collection and analysis (e.g. household

surveys), capacity needs to apply measurement technologies (e.g. such as remote sensing), and communication and interpretation challenges of complex indicators (e.g. adjusted economic measures). Most notable is the lack of IGG data and measurement approaches in developing countries, which is also due to weak institutional mandates and statistical capacity for data collection and analysis.

4.1 Economic values of stocks and flows of natural assets

Despite an increasing application of natural capital accounting, the valuation of stocks and flows of natural assets remains challenging. One reason is that values are very context specific, as they depend on the specific ecosystem services provided and the beneficiaries from these services, which varies across locations. While the number of case studies is growing, it is difficult to translate these ecosystem- and location-specific findings into values at a more aggregate level.

The statistical standards and experimental approaches outlined by SEEA for developing integrated environmental and economic accounts provide guidance for the valuation of the stocks and flows related to natural assets. Preparing such accounts will not only produce data on the values of different types of natural assets, but also other indicators along the way. Where countries find it challenging to compile environmental accounts, capacity building and institutional support through global programs (e.g. WAVES) can facilitate the valuation of natural assets. Although applying SEEA will close some of the existing IGG data gaps, some general challenges remain for the valuation of natural assets. And in practice, the lack implementation of SEEA is a measurement gap certainly worth flagging.

For instance, the valuation of natural assets may require new methods that consider broader social values that go beyond monetary values. Existing methodologies for monetary valuation of non-market benefits all have their limitations. Monetary valuation also requires calculation of marginal values (i.e. for small incremental changes in the stocks or flows), which is generally difficult in the presence of non-linear relationships between the remaining stocks of natural assets (e.g. forest area) and the flow of ecosystem services (e.g. water filtration) (Farley, 2012). Many natural assets may in fact be poorly suited for monetary valuation. Deliberative and participatory methods that derive social values from group exercises could be a new way to determine the importance of natural asset flows and stocks, especially where monetary valuation is technically too demanding or politically too contested (Wilson & Howarth, 2002; Turner, Morse-Jones & Fisher , 2010).

4.2 Qualitative dimensions of natural assets

Indicators measuring qualitative aspects of natural assets are rare, as this would require data that are difficult to collect. Often it is easier to observe and track changes in quantities of natural assets or biophysical flows of ecosystem goods and services. For example, data on water supply or forest cover are much more common than data on water pollution or forest health. Measuring such qualitative aspects would require the monitoring of pollution or functionality on the ground, which can be extremely costly in practice.

Yet a number of new methods to generate such data are becoming available. Remote sensing offers an opportunity to monitor real-time data on quantitative and qualitative environmental aspects at the global level. Combined with data analysis and further modelling, such data can be used to generate useful IGG indicators. For example, satellite data are being combined with transport models to derive ground-based estimates of air pollution where monitored data are not collected from on-the-ground stations. It can also be combined with ground readings to provide more accurate hybrid estimates (OECD, 2016b). Enhancing the use of such measurement methods and developing frameworks for compiling the data and constructing IGG indicators would improve the monitoring of natural asset stock quality.

4.3 Sustainable use of natural assets and ecological thresholds

When measuring the use of natural assets, in particular the extraction of natural resources, actual use levels must be compared against levels that are deemed sustainable in the long-run. For example, the increasing extraction of renewable resources, such as fish or timber, will not necessarily indicate a threat as long as extraction rates remain below the system's capacity to renew these resources. Without defining sustainable use (or extraction or harvest) rates, data on the current stocks and flows alone cannot identify threats to natural assets.

Establishing such sustainable levels will require an understanding of the functioning of ecosystems subject to non-linearity. It is often assumed that ecosystem goods and services are provided linearly at a steady rate (e.g. a certain amount of clean water per hectare of forest areas). Yet ecosystem processes are characterized by thresholds and ecological limits, which is conditioned by temporal and spatial variability (e.g. when a highly degraded land area during a drought period cannot anymore support basic services). Passing such thresholds and limits could lead to tipping points beyond which the ecosystem changes its functions.

Knowledge is limited on how ecosystems behave at the limits of their tolerance for disturbance, how they recover from stress, and how they adapt once certain thresholds are passed. Better understanding of such thresholds can help in the development of further footprint metrics and improve measurements of resilience of ecological systems. Exploratory data analysis and ecosystem modelling can help to identify such thresholds.

4.4 Combining economic and environmental data at the microlevel

Although various resource efficiency metrics are calculated at the national level based on economic and environmental metrics, more microlevel data are needed to better understand the variation of resource efficiency between geographical areas, economic sectors or consumption activities. National data may often be too broad for assessment and are often an aggregate of underlying transformations in a multitude of sectors, firms and households.

Plant level inventories collected over time can provide data on key industrial point pollution. For example, such data are collected through the US Toxics Release Inventory and National Air Emissions Inventory, the Pollutant Release and Transfer Registries (PRTR) of the EU, and the Canadian National Pollutant Release Inventory. In parallel, many countries conduct manufacturing surveys, and private data collectors track corporate financial accounts – meaning that with little effort, this information could be compiled and used in IGG research (EPA, 2013). Some attempts are already ongoing (e.g. combining environmental data – pollutant releases – with annual manufacturing surveys into a single data set at Statistics Canada).

Yet international harmonization for data collection and classifications will be needed to make such data comparable between countries. Efforts are proceeding at a slow pace, for example through OECD's Taskforce on PRTRs. Overall, filling this gap offers potential to improve both natural-asset base indicators and resource efficiency indicators, and to give ground for various strands of empirical research on the IGG transformation and the underlying impacts on economic activity.

4.5 Resilience of socioeconomic systems to ecological shocks

Notwithstanding the numerous initiatives and data sources related to climate and disaster risks and impacts and adaptive capacities, there is an urgent need to better measure the resilience of socioeconomic systems in light of such risks. The resilience of socioeconomic systems, such as households, communities, firms, (sub-) national institutions, however, is partly a result of the

resilience of biophysical systems (both natural and human-made), which demonstrates the interlinked nature of economy, society and the environment. Nonetheless, there has been limited effort to measure these resilience dimensions to date.

Challenges for measuring resilience are manifold and will require a number of solutions. First of all, operational definitions of resilience are needed. Although broad definitions exist, such as by the IPCC (2014), these definitions are often difficult to translate into measureable variables. Another challenge relates to the fact that resilience is generally difficult to observe as it requires comparing a system under stress with the same system in absence of the stress. Normally, only one of these two states is observed. Hence, instead of relying on monitored data, measuring resilience may actually require new approaches, such as modelling. Moreover, there are a variety of data gaps associated with certain aspects of resilience, such risk preparedness, response capacity and recovery time, all of which will require investments in data collection.

4.6 Green jobs, investments and other opportunities

A pressing measurement gap relates to the lack of good data and hence analysis on the extent of the green transformation, such as so-called green jobs, investments and other opportunities. One of the central tenets of IGG is that environmentally friendly development can become a driver of job creation, investments and economic development and does not need to be, on the aggregate, economically inferior to “dirtier” development tracks. In the absence of relevant data, it may not be possible to assess these impacts, which may be particularly relevant in the short- and medium-term.

Measuring opportunities is inherently problematic when assessing ex ante effects of any economic transition. Data on economic risks, such as jobs at risk in traditional, industrial sectors, may be easier to identify than potentially created jobs in “green” sectors. This imbalance can incite opposition to green policies.

Labelling investment flows, trade, patents and jobs as “green” is relatively cumbersome. Hence, such labelling is not well established in national statistical programs. The challenge is twofold. First, it is not easy to identify what actually constitutes an opportunity, and what is an effort or result of policies. For example, green investment, innovation or jobs can often be regarded not as opportunities as such, but rather signals of transformation or the effort made towards IGG. Second, in practice it is difficult to draw a line between what is and what is not green (GGKP, 2013). Often there is little agreement at the national level as to what is green and this meaning is highly context-dependent.

In order to respond to the need for production of harmonized and comparable statistical data on employment in the environmental sector and green jobs, the ILO has developed a standard conceptual framework along with appropriate operational definitions and measurement methods, which were adopted by the 19th International Conference of Labour Statisticians in 2013.[37] According to these guidelines, the employment in the environmental sector includes not only those involved in the production of environmental goods and services, but also includes workers whose duties involve making the production processes of their economic units more environmentally friendly, or making more efficient use of natural resources. It also makes reference to the quality of these jobs. Nevertheless, the application of these definitions remains difficult and comprehensive data on green jobs are still very limited.

[37] http://www.ilo.org/global/statistics-and-databases/standards-and-guidelines/guidelines-adopted-by-international-conferences-of-labour-statisticians/WCMS_230736/lang--en/index.htm

4.7 Aggregate impacts of environmental policies

Embarking on IGG strategies often comes with a lot of promises or expectations, but it also comes with worries regarding the associated costs of environmental policies. However, in practice most of these claims remain empirically unverified or verified in an unsatisfactory manner, largely due to limited data on the economic effects of environmental policies. Measures for the stringency of environmental policies are scarce, underdeveloped and often suffer from poor coverage (Brunel & Levinson, 2013; Botta & Kozluk, 2014).

Monitoring IGG policy efforts is essential to compare country action to achieve a greener future, as well as to empirically assess the effects of policies and their design features and the need for additional or compensatory policy action. While there is unlikely to be one perfect way to measure environmental policies, advances on this issue can encourage research on the empirical foundations of IGG, verify various claims on trade-offs and costs, and push forward the reform agenda. Notably, this has been recognized as a prominent data gap by the GGKP Research Committee on Trade and Competitiveness (Scrieciu, 2015).

4.8 Distributional effects of environmental changes or policies

Regarding the inclusiveness dimension of green growth, we also need to better measure who is affected by environmental changes and environmental policies. The resulting risks and benefits are generally unevenly distributed across space and between different groups of society (sometimes even across time). The impacts on different socioeconomic groups depend on the location of different groups, as well as their vulnerability to the risks or their ability to capture benefits. Combining data on environmental indicators, socioeconomic status and well-being allows for assessing which groups are most affected by environmental risks and which groups benefit most from environmental goods and services.

Many environmental indicators are based on geo-spatial datasets, which could be overlaid with population maps and other geo-coded socioeconomic data. For example, high-resolution deforestation data from Hansen et al. (2014) can be used with poverty maps (where available) to identify whether environmental degradation is a concern in poorer areas. Geo-spatial tools that can model the spatial distribution of ecosystem services, such as the Artificial Intelligence for Ecosystem Services (Aries) or the Integrated Valuation of Ecosystem Services and Tradeoffs (InVEST) model allow ecosystem beneficiaries to be mapped.

Alternatively, the integration of environmental questions into household surveys, such as the Livings Standards Measurement Surveys, is another possibility to obtain such data. Yet designing surveys and collecting such data can take time and be costly. And it can be difficult to make household surveys representative of particular vulnerable or marginal groups. Generally, it has proven challenging to integrate economic and environmental data, not to mention further considering social dimensions.

5. Conclusions: the way forward

The previous sections have demonstrated some significant data gaps that apply to existing IGG measurement approaches within the five measurement themes identified in this paper. The lack of sufficient data coverage across countries and time should not be used as a rational for eliminating these indicators from IGG measurement frameworks. Rather, demand for such indicators should increase in order to stimulate investment in research and monitoring systems and data collection. There is a risk that if these investments are not made sufficiently early, concepts and measurement methodologies for IGG may not develop. Admittedly, any data collection and processing has a cost, and all costs need to be weighed against the benefits from such data.

New statistical frameworks and standards will facilitate data collection and better measurement of IGG themes. With SEEA, global efforts will advance to expand integrated environmental and economic accounting, which can produce not only adjusted economic measures, but also a variety of other IGG-relevant indicators, such as physical data on ecosystem service flows. Nonetheless, the uptake of such standards could remain low, especially for countries that cannot overcome the challenges inherent in putting together complex indicators in data-poor environments because of weak institutional and statistical capacities.

Most importantly, the adoption of the SDGs provides a unique opportunity to create demand for new indicators and data and to spur investment in data collection and analysis capacities, as was the case after the adoption of the MDGs, which led to new data efforts in areas such as poverty, education and health. Building on the indicator framework that will be developed to monitor the targets of the SDGs, such as, for example, for inclusive and sustainable economic growth (goal 8) and sustainable consumption and production (goal 12) offers a unique chance to address some of the IGG measurement gaps. Yet it remains to be seen how developing countries, whose national statistical systems will be challenged by the 169 targets to monitor, can be supported towards implementing the SDG indicators framework that will be adopted in March of 2016.

Promisingly, there are a few innovative solutions that can reduce the costs for data collection for IGG themes. Remote sensing can measure a variety of environmental aspects and can be relatively low-cost considering the huge public benefits from such data. Crowdsourcing is another possibility for collecting new data through mobile technologies, such as smart phones or online platforms. Some initial applications of this type of crowdsourcing of data are beginning to emerge in the environmental field (Hasenfratz, 2012; Maher et al., 2014).

Furthermore, engaging the private sector is another strategy to mobilize data. Many companies generate huge databases for proprietary use (e.g. the disaster databases managed by insurance companies) of which small selections could be made available without much cost. In addition, public-private cooperation could fund new data collection efforts, such as seen by the example of the Aqueduct Water Risk Atlas of WRI.

In addition to improved data collection, better use of data is needed. In many instances data are available but are not easily accessible or used properly. Making data available through open web-platforms and providing guidance on how to use such data will be a critical endeavour for ensuring better measurement of IGG as well as many other aspects. Similarly, many existing environmental indicators are underutilized because they are often not easy to understand. Improved communication of the concepts and interpretation of the data is equally important to facilitate the uptake of indicators.

Moving forward, it will be important to prioritize the measurement gaps and mobilize investment for indicator development and data collection. Addressing the most pressing IGG measurement needs will help to track progress towards IGG, inform and improve policymaking, and facilitate the process of mainstreaming the IGG concept.

Annex: Global data sources by theme

Table A1. Multi-country data sources for natural assets

Measurement Category	Measurement Aspect	Potential Indicators	Data Source	Data Coverage	Notes	Link
Land and soil resources	Agricultural land	Current agricultural area under different crops	FAO	Global; yearly updates	Official data, based on country self-reporting	http://faostat3.fao.org/home/E
	Value of agricultural land	Net Present Value of production potential of agricultural land	World Bank Wealth of Nations	Ca. 130 countries; for 1995, 2000, 2005, 2008, 2010, regular updates	Methodology currently updated	http://data.worldbank.org/data-catalog/wealth-of-nations
	Land degradation	Topsoil loss of agricultural land	FAO Global Assessment of Soil Degradation (GLASOD)	Ca. 145 countries; 1991		http://faostat3.fao.org/download/E/ES/E
		Normalized Difference Vegetation Index	University of Maryland – Global Land Cover Facility based on Global Inventory Modeling and Mapping Studies (GIMMS) data	Global map (8x8km); bi-weekly data 1982–2006	These data cannot be directly used and require further analysis (see e.g. Bai et al. 2008; or Bao Le, et al., 2014). Also, there are other sources of similar	http://glcf.umd.edu/data/ndvi/

			from Moderate Resolution Imaging Spectroradiometer (MODIS)		type available (see OECD, 2016b)	
			NASA Earth Observations based on data from Moderate Resolution Imaging Spectroradiometer (MODIS)	Global map (4x4km); monthly data from 2000, regular updates	These data cannot be directly used and require further analysis (see e.g. Bai et al., 2008; or Bao Le et. al, 2014).	http://neo.sci.gsfc.nasa.gov/view.php?datasetId=MOD13A2_M_NDVI
Forests and timber	Forest land	Land with different forest types and changes over time	FAO Forest Resource Assessment	Most countries; 1990, 2000, 2005, 2010, updates every five years	Official data based on country self-reporting	http://www.fao.org/forestry/fra/
		Land with tree cover gain (>25% canopy cover density for any vegetation above 5m) and changes over time	WRI Global Forest Watch based on University of Maryland analysis	Global map (30x30m); annual data from 2000, updates are planned	Results shown in Hansen et al. 2013	http://www.globalforestwatch.org/

		Land with tree cover gain	WRI Global Forest Watch based on University of Maryland analysis	Global map (30x30m); annual data 2000-2012	Results shown in Hansen et al. 2013	http://www.globalforestwatch.org/
	Value of forest land	NPV of rents from sustainable roundwood production non-timber forest resources	World Bank Wealth of Nations	130 countries; for 1995, 2000, 2005, 2008, 2010, regular updates	Methodology currently updated	http://data.worldbank.org/data-catalog/wealth-of-nations
	Timber stocks	Volume of industrial roundwood and woodfuel	FAO Forest Resource Assessment	Most countries; 1990, 2000, 2005	Official data based on country self-reporting, widely used	http://www.fao.org/forestry/fra/fra2010/en/
	Value of forest resource depletion	Value of excess roundwood harvest that is beyond natural growth (in US$ or % of GNI)	World Bank World Development Indicators	Ca. 130 countries; 1970-2013, yearly updates	Methodology currently updated	http://data.worldbank.org/indicator/NY.ADJ.DFOR.GN.ZS
Water resources	Available renewable freshwater resources	Total renewable water resources	FAO Aquastat	200 countries; yearly updates		http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en

	Areas/population exposed to water scarcity	Baseline water stress	WRI Aqueduct	Global coverage; 2014 only	When overlaid with spatial population data, the population exposed to water stress can be calculated	http://www.wri.org/our-work/project/aqueduct/aqueduct-atlas
	Rainfall deficit	Global Aridity Index	CGIAR – Consortium for Spatial Information	Global coverage (1x1km), average for 1950-2000 only	Based on of precipitation, temperature and potential evapotranspiration	http://www.cgiar-csi.org/data/global-aridity-and-pet-database
	Severity of drought conditions	Standardized Precipitation and Evaporation Index	Global SPEI database	Global (50x50km), 1901-2013	Based on monthly precipitation and potential evapotranspiration from the Climatic Research Unit	http://sac.csic.es/spei/database.html
	Water resources exposed to harmful pollution levels	Surface and groundwater quality	UNEP Global Environment Monitoring System (GEMS) Water Programme	Global (4,100 stations from all around the world) but country coverage and years vary	Measured parameters and frequency varies despite standardized methods	http://www.unep.org/gemswater/GlobalNetwork/tabid/78238/Default.aspx
	Freshwater resources and abstractions	Aquifer recharge, evapotranspiration, groundwater	OECD Environment Statistics	OECD, 1980-2013	Official data based on country self-reporting	http://stats.oecd.org/index.aspx?datasetcode=WATER_ABSTRACT

		for abstraction, inflow, outflow, precipitation, total resource; gross abstraction for public supply, agriculture, manufacturing, electricity production				
	Lake and river quality	Nitrates, phosphorus	OECD Environment Statistics	OECD, 1980-2013	Official data based on country self-reporting	http://stats.oecd.org/index.aspx?datasetcode=WATER_QUALITY
Minerals and energy resources	Available stocks and reserves	Metallic and nonmetallic mineral resources	US Geological Survey	Global; current stocks only		http://mrdata.usgs.gov/mineral-resources/mrds-global.html
	Value of energy extraction and depletion	Mineral depletion	World Bank World Development Indicators	Ca. 130 countries, 1970-2013; yearly updates		http://data.worldbank.org/indicator/NY.ADJ.DMIN.CD
	Natural resource	Extraction and remaining stocks of	OECD Natural Resource Accounts	Selected countries, 1980-2014, ISIC Rev. 4	Country coverage will be progressively expanded as	http://stats.oecd.org

	accounts (SEEA)	fossil fuels (oil, natural gas, hard and soft coal) and minerals (iron ore, bauxite, copper, lead, nickel, tin, zinc, gold, silver, phosphate)			countries adopt the SEEA standard.	
Oceans and fish stocks	Proportion of fish stocks overexploited or collapsed	Proportion of fish stocks overexploited or collapsed	Yale University Environmental Performance Index (based on Sea Around Us Project)	134 countries; 1951-2011		http://epi.yale.edu/content/fisheries-raw-data-file
Biodiversity	Species abundance	Benefits index for biodiversity	GEF	Global coverage; 2005 and 2008 only	Based on De Pandey et al., 2006	http://data.worldbank.org/indicator/ER.BDV.TOTL.XQ
	Number of threatened species	Threatened species	World Bank World Development Indicators (based on IUCN, UNEP)	Global coverage; 2014 data available		http://wdi.worldbank.org/table/3.4
Air pollution emissions	Air pollution emissions accounts (under SEEA)	PM2.5, CO, NMVOC, SOx, NOx, and GHGs (CO2, CH4, N2O,	OECD Air Emissions Accounts	Selected countries, 2000-2013, ISIC Rev. 4	Country coverage will be progressively expanded as	http://stats.oecd.org/index.aspx?datasetcode=AEA

		HFC, PFC, SF6),			countries adopt the SEEA standard.	
Climate	CO2 and other GHG emissions	Direct GHGs (CO2, CH4, N2O, PFCs, HFCs, SF6)	UNFCCC	43 (Annex I countries) for 1990-2012; for non-Annex I countries data coverage (in terms of year and GHG varies)	Data reported in national GHG inventories; for non-Annex I countries data is always outdated	http://unfccc.int/ghg_data/ghg_data_unfccc/items/4146.php
		GHG emissions (by gas and sector)	WRI Climate Data Explorer (CAIT2.0)	All countries; 1990-2011		
		CO2 emissions from fuel combustion	IEA	All countries; 1960-2013		http://stats.oecd.org/index.aspx?datasetcode=BIGCO2
		CO2 emissions (by sector) and	World Bank World Development Indicators (based on Carbon Dioxide Information Analysis Center, Environmental Sciences Division, Oak Ridge National Laboratory)	All countries; 1970-2010		http://data.worldbank.org/indicator/EN.ATM.CO2E.KT

		Other GHG emissions (by gas)	World Bank World Development Indicators (based on IEA, OECD)	Ca. 150 countries; 1990, 2000, 2005, 2008, 2010		http://data.worldbank.org/indicator/EN.ATM.GHGO.KT.CE

Table A.2. Multi-country data sources for resource efficiency

Measurement Categories	Measurement Aspect	Potential Indicators	Data Source	Data Coverage	Notes	Link
Productivity/ Efficiency	CO_2 productivity	Real income per energy-related CO_2 emissions	OECD Green Growth Indicators	OECD countries; 1995, 2000, 2005, 2008, 2009		https://stats.oecd.org/Index.aspx?DataSetCode=GREEN_GROWTH
	CO_2 intensity	CO_2 emissions per unit of GDP	World Bank World Development Indicators (based on Carbon Dioxide Information Analysis Center, Environmental Sciences Division, Oak Ridge National Laboratory)	Most countries;1990-2010		http://data.worldbank.org/indicator/EN.ATM.CO2E.PP.GD?page=5
		CO_2 emissions from electricity and heat production, total (% of total fuel combustion)	World Bank World Development Indicators (based on IEA, OECD)	Ca. 170 countries; 1971-2011		http://data.worldbank.org/indicator/EN.CO2.ETOT.ZS
	Energy intensity	Primary energy intensity	Sustainable Energy for All Initiative (based on UN, WDI, IEA)	180+ countries; 1990, 2010		http://www.se4all.org/tracking-progress/

		Final energy intensity	Sustainable Energy for All Initiative (based on UN, WDI, IEA)	180+ countries; 1990, 2010		http://www.se4all.org/tracking-progress
	Material productivity	Domestic and total (non-energy) material consumption and productivity (incl. biomass for food and feed, wood, construction minerals, industrial minerals, fossil energy, metals)	OECD	OECD and BRIICS; 1980-2011		http://stats.oecd.org/index.aspx?datasetcode=MATERIAL_RESOURCES
	Water intensity	Agricultural, industrial and municipal water withdrawals	World Bank World Development Indicators (based on FAO)	Most countries; every five years, 2012 latest	These measures can be combined with data on economic production to produce a water intensity measure.	http://data.worldbank.org/topic/economy-and-growth#tp_wdi
		Water consumption	OECD	OECD countries; 1985-2010 (every five years)		http://www.oecd-ilibrary.org/sites/factbook-2013-en/09/01/01/index.html?itemId=/content/chapter/factbook-2013-68-en

	Green productivity	Green (environmentally adjusted) multifactor productivity	OECD	OECD & G20 countries; 1991-2013	Accounts for environmental inputs (natural resources) and adjusts for environmental “bads” (degradation) (Brandt et al. 2014, OECD, 2016a)	https://stats.oecd.org
Waste	Waste generation	Hazardous waste generation and municipal waste collection and treatment	UN Department of Economic and Social Affairs	Ca. 80 countries; 1995, 2003-2009		http://unstats.un.org/unsd/environment/hazardous.htm
		Municipal and total amounts of waste generated by sector (agriculture, manufacturing, energy production, households)	OECD	OECD, 1980-2012	Official data based on country self-reporting	http://stats.oecd.org/index.aspx?datasetcode=WSECTOR

		Municipal waste generation	EEA	Europe only; 1995-2009		http://www.eea.europa.eu/data-and-maps/indicators/municipal-waste-generation
	Waste collection	Municipal waste collected	UN Department of Economic and Social Affairs	Ca. 80 countries; year varies (1999-2009)		http://unstats.un.org/unsd/environment/wastetreatment.htm
	Waste treatment	Municipal waste treated (landfilled/incinerated/composted)	UN Department of Economic and Social Affairs	Ca. 80 countries; year varies (1999-2009)		http://unstats.un.org/unsd/environment/wastetreatment.htm
		Wastewater treatment	Yale University Environmental Performance Index (based on Sea Around Us Project)	Ca. 180 countries; 2012 only		http://epi.yale.edu/our-methods/water-resources#tab-1
Recycling and renewables	Recycling capacity	Municipal waste recycled	UN Department of Economic and Social Affairs	Ca. 80 countries; year varies (1999-2009)		http://unstats.un.org/unsd/environment/wastetreatment.htm
	Recycling of municipal waste	Municipal waste treated, recycled, composted,	OECD	OECD, 1980-2012	Official data based on	http://stats.oecd.org/index.aspx?datasetcode=WSECTOR

		incinerated, landfilled			country self-reporting	
	Use of renewables	Electricity production from renewable sources	World Bank World Development Indicators (based on IEA and OECD data)	Ca. 170 countries; 1960-2012		http://data.worldbank.org/indicator/EG.ELC.RNEW.KH

Table A.3. Multi-country data sources for risks and resilience

Measurement Categories	Measurement Aspect	Potential Indicators	Data Source	Data Coverage	Notes	Link
Climate and disaster risk impacts	Causalities	Number of dead, injured, homeless and affected natural disasters in the past	EM-Dat (WHO collaborating Centre for Research on the Epidemiology of Disasters (CRED))	All countries; 1900-2014, updated annually	Monitored data by disaster type	http://www.emdat.be/database
		Number of fatalities by natural disasters in the past	MunichRe NatCat Dataservice	All countries; 2004-2014, updated annually	Monitored data by natural disaster type comprising some 30,000 records	http://www.munichre.com/natcatservice
		Number of dead or missing, injured and homeless caused by natural catastrophes in the past	SwissRe database	All countries; 1970-2014, updated annually	Monitored data by type of man-made and natural catastrophes	http://www.swissre.com/sigma/
	Economic damages	Value of economic damages by natural	EM-Dat (WHO collaborating Centre for Research on the	All countries; 1970-2014, updated annually	Monitored data by disaster type	http://www.emdat.be/database

		disasters in the past	Epidemiology of Disasters (CRED))			
		Value of economic losses (incl. uninsured) by past natural disasters	MunichRe NatCatSERVICE	All countries; 2004-2014, updated annually	Monitored data by disaster type comprising some 30,000 records	http://www.munichre.com/natcatservice
		Value of economic losses (incl. uninsured) by past natural catastrophes	SwissRe database	All countries; 1970-2014, updated annually	Monitored data by type of man-made and natural catastrophes	http://www.swissre.com/sigma/
		Value of economic damages and losses	Global Facility of Disaster Reduction and Recovery Global Damage and Loss Database	Developing countries; 1974-2010	Monitored data by type of natural disaster	https://www.gfdrr.org/damageandlosses
		Expected damage of future flood risks	WRI Aqueduct Global Flood Risk Maps based on Ward et al. 2013	Global map (0.5°×0.5° resolution); current and future (2030)	Modelled estimates based on stage-damage function, a land use map, a map of estimated urban asset per km2 and inundation modelling	http://www.wri.org/resources/data-sets/aqueduct-global-flood-risk-maps
	Propensity to experience climate and	Effects of natural	Germanwatch's Global Climate Risk Index based	All countries; 1994-2013	Index based on number of deaths, number of deaths per	http://germanwatch.org/en/cri

	disaster impacts	disasters in the past	on Munich RE NatCatSERVICE		100,000 inhabitants, sum of losses, losses per unit of GDP	
			IDB's Local Disaster Index based on data from DesInventar database	Latin American countries; 2001-2008	Index based on number of deaths, number of people affected and economic losses in each municipality	http://www.iadb.org/en/topics/natural-disasters/disaster-risk-indicators/disaster-risk-indicators,1456.html
Exposure and vulnerability to risks	People and economic assets in high-risk areas	Population exposed to future flood risks	WRI Aqueduct Global Flood Risk Maps based on Ward et al. 2013	Global map (30"x30" resolution); current and future (2030)	Inundation modelling based on historic data, different flood return periods and future climate change projections	http://www.wri.org/resources/data-sets/aqueduct-global-flood-risk-maps
		GDP affected exposed to future flood risks				
		Percent of population living less than 5m above sea-level	World Bank World Development Indicators (based on CIESIN/SEDAC)	202 countries; for 1990, 2000, 2010		http://data.worldbank.org/indicator/EN.POP.EL5M.ZS
		Fragility and exposure of human and economic activity in disaster-	IDB's Prevalent Vulnerability Index	Latin American countries; 2007 only	Measured as an index comprising several subindicators	http://www.iadb.org/en/topics/natural-disasters/disaster-risk-indicators/disaster-risk-indicators,1456.html

		prone areas and the social and human capacity to absorb disaster impacts				
	Production sensitive to climate impacts	Percent of land under ratified agriculture	FAO Aquastat	Ca 80 countries; 2001-2012		http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en
	Population with access to social protection	Coverage of different types of social insurance and social transfers	World Bank Aspire Database	Ca. 112 developing countries; year varies by country	Data based on nationally representative household survey data	http://datatopics.worldbank.org/aspire/
	Population exposure to harmful levels of air pollution	Mean exposure to PM2.5 and population exposed to PM2.5 levels exceeding WHO guideline	World Bank, World Development Indicators (based on IHME and WHO)	Ca 200 countries; 1990, 2005, 2010		http://data.worldbank.org/indicator/EN.ATM.PM25.MC.ZS
			OECD (based on data by Brauer et al. 2015)	OECD and G20 countries, 1990-2013, at the national,	(OECD, 2016b)	https://stats.oecd.org

		value (% of total)		regional and metropolitan levels		
Responsiveness/adaptation	Government action for disaster risk reduction	Progress towards disaster risk reduction goals	Hyogo Framework progress reports	101 countries; 2007-2013	Data self-reported by countries based on subjective scores	http://data.worldbank.org/indicator/EN.CLC.DRSK.XQ
	Government capacity to manage disaster risks	Legal, institutional and financial conditions to implement disaster risks management policies	IDB's Governance and Public Policy for DRM (iGOPP)	11 Latin American countries; 2013	Index based on a combination of 246 binary indicators, which aim to verify enforcement of actual policies	http://publications.iadb.org/handle/11319/6738?locale-attribute=en
		Capacity to identify and reduce risks, respond and recover from catastrophes as well as to provide financial protection and risk transfer	IDB's Disaster Risk Management Index	Latin American countries; 2008 only	Measured as an index comprising several subindicators	http://www.iadb.org/en/topics/natural-disasters/disaster-risk-indicators/disaster-risk-indicators,1456.html
		Capacity to pay for	IDB's Disaster Deficit Index	Latin American countries; 2008 only	Measured as the ratio of economic loss to the state	http://www.iadb.org/en/topics/natural-disasters/disaster-risk-

		disaster recovery			financial capacity to pay for recovery	indicators/disaster-risk-indicators,1456.html
Combined	Vulnerability to climate risks	Index based on sensitivity, exposure and adaptation capacity	Maplecroft Climate Change Vulnerability Index	All countries; yearly updated	Measured by the sensitivity of populations, the physical exposure of countries, and governmental capacity to adapt to climate change over the next 30 years	https://maplecroft.com/themes/cc/
	Risk to humanitarian crises and natural disasters	Index based on hazard and exposure, vulnerability, and lack of coping capacity	European Union Joint Research Centre	All countries; from 2011 onwards, yearly updates	Each dimension encompasses different categories, which are user-driven concepts related to the needs of humanitarian and resilience actors	http://www.inform-index.org/
	Adaptation	Index based on vulnerability and readiness	University of Notre Dame		Each category includes several subcategories	http://index.gain.org/

Table A.4. Multi-country data sources for economic opportunities and efforts

Measurement Categories	Measurement Aspect	Potential Indicators	Data Source	Data Coverage	Notes	Link
Environmental regulation and planning	Protected areas	Terrestrial and marine protected areas	World Bank World Development Indicators (based on IUCN &UNEP-WCMC)	All countries; 1990-2012		http://data.worldbank.org/indicator/ER.PTD.TOTL.ZS
	Environmental protection expenditure	Environmental protection expenditure as % of GDP	OECD	OECD, 1990-2013	Official data based on country self-reporting (OECD/Eurostat questionnaire)	http://stats.oecd.org/index.aspx?datasetcode=EPER
	Fossil fuel subsidies[38]	Price-gap based fossil fuel subsidies	IEA	39 (primarily developing) countries; 2007-2011	IEA has been constructing this dataset for over a decade uses price-gap approach	http://www.worldenergyoutlook.org/resources/energysubsidies/fossilfuelsubsidydatabase/
		Budgetary transfer and tax expenditure-based fossil fuel subsidies	OECD	OECD and G20 countries; 2005-2013	OECD uses budgetary transfers and tax expenditures and broader range of measures than IEA	http://www.oecd.org/site/tadffss/

[38] Difference between IEA and OECD explained: http://www.oecd.org/site/tadffss/

	Environmental Policy Stringency	Index of stringency of Environmental Policies	OECD	24 OECD countries; 1990-2012	Composite indicators based on individual policies, new update including BRIICS countries in early 2016	http://oe.cd/OQ
Environmental taxes and government spending	Environmentally related tax revenues	Revenues from taxes, charges and fees on energy, motor vehicles and transport, water and wastewater, waste management, and ozone depleting substances, mining and quarrying	OECD	48 countries (OECD and selected developing countries); 1994-2013		http://stats.oecd.org/index.aspx?datasetcode=ENV_ENVPOLICY
Innovation and business environment	R&D expenditure for energy technology	R&D expenditure for energy technology as % of GDP	IEA	Selected IEA countries; 1990-2012	IEA data covers R&D expenditures, private and public, for various energy categories (e.g. renewables, energy efficiency).	http://www.iea.org/statistics/topics/rdd/
	Patents in so-called environment related technologies	Counts of patented inventions and co-inventions by inventor country; counts of patent	OECD	Global; 1980-2012	Based on the OECD ENVTECH definition and the PATSTAT database	http://stats.oecd.org/index.aspx?datasetcode=PAT_DEV; http://www.oecd.org/env/indicators-modelling-

		application by office				outlooks/green-patents.htm
Green transformation / opportunities	"Green" jobs	Employment in Environmental Goods and Service Sectors	Eurostat	Ca. 10 EU/OECD countries; years depend on country	Data collected through surveys sent out to member states; data covers environmental protection activities and resource management activities	http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_ac_egss1&lang=en
	"Green" output	Production, value added and exports in the environmental goods and services sector	Eurostat	Ca. 10 EU/OECD countries; years depend on country	Data collected through surveys sent out to member states; data covers environmental protection activities and resource management activities	http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=env_ac_egss2&lang=en

Table A.5. Multi-country data sources for inclusiveness

Measurement categories	Measurement examples	Potential indicators	Data source	Data coverage	Notes	Link
Access to environmental goods and services	Access to water services	Access to improved sanitation	World Bank World Development Indicators (based on WHO/JMP)	185 countries, 1980-2012		http://data.worldbank.org/indicator/SH.STA.ACSN
		Access to improved drinking water	World Bank World Development Indicators (based on WHO/JMP)	185 countries, 1980-2012		http://data.worldbank.org/indicator/SH.H2O.SAFE.ZS
	Access to clean energy	Access to electricity and to non-solid fuel	Sustainable Energy for All Initiative (based on DHS and other data sources)	>180 countries, 1990, 2000, 2010		http://data.worldbank.org/data-catalog/sustainable-energy-for-all
	Population threatened by poor air quality	Population exposed to PM2.5 levels exceeding WHO guideline value (% of total)	World Bank World Development Indicators (based on IHME and WHO)	All countries, 1990, 2005, 2010		http://data.worldbank.org/indicator/EN.ATM.PM25.MC.ZS
			OECD (based on data by GBD; Brauer et al. 2015)	OECD and G20 countries, 1990-2013, at the national,	(OECD, 2016b)	https://stats.oecd.org

				regional and metropolitan levels		
Participation in environmental decision-making	Women with secure land ownership	Women who own land	FAO Gender and Land Rights Database (based on different survey sources)	Ca. 20 developing countries, 2010		http://www.fao.org/gender-landrights-database/data-map/statistics/en/

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