



IUCN Environmental Economics Occasional Paper Series

Beyond GDP: Measuring Progress Towards a Green Economy

Abstract

IUCN joins those who recognize GDP as a misused, inaccurate and insufficient indicator of human wellbeing, and expresses its willingness to support governments, and others, in the development of alternative measures of economic prosperity, building notably on efforts to go 'beyond GDP'. The objective of this report is to provide an overview of alternative macroeconomic indicators of economic progress and sustainable development, focusing in particular on efforts to incorporate environmental and natural resource measurements that are not typically included in traditional measures. The report first provides an introduction and overview of traditional measures of economic well-being, in particular, Gross Domestic Product (GDP) and the issues that arise when it is extending beyond its intended use as a measure of economic performance to use as a measure of overall societal well-being. The report then summarizes and describes several broad sources of environmental value and natural capital currently of interest for inclusion in national welfare indicators. Section III identifies and describes several of the most widely used indicators of environmental progress and identifies the key features of each indicator, focusing especially on the measurement of environmental services identified in previous section. The report then provides a comparison of selected nations' rankings across five indicators for which consistent data could be obtained and analyzes a small subset of countries' performance over recent decades. The final section concludes with a brief summary of the continuing barriers to using these alternative measures of economic development, as well as an overview of recommendations from policy experts currently developing, refining, and applying various indicators.

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Beyond GDP Measuring Progress Towards a Green Economy

Overview

Since the 1930s, the most widely used measure of a nation's economic progress has been changes in Gross Domestic Product (GDP). GDP measures the flow of income and expenditures through a market economy by adding together the value of all final goods and services produced in a nation in a given time period. This is achieved by adding together a nation's personal consumption expenditures, government expenditures, net exports, and net capital formation (investment). Figure 1 shows a simple representation of the circular-flow of income and spending within a market economy: the use of capital by individuals, businesses, and government to produce goods and services.

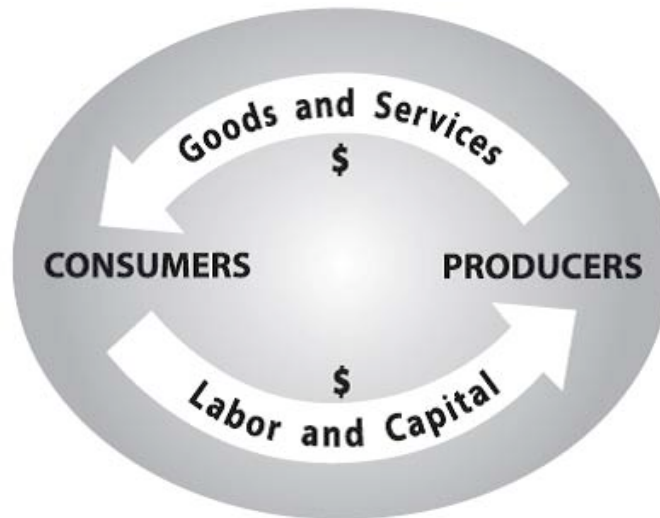


Figure 1: Standard View of Economic Activity
Source: Costanza et al. (2009)

Since its introduction GDP has been used to measure these flows of output and income through the economy and economists have warned that it is a specialized tool and treating it as an indicator of overall societal well-being is inaccurate and misleading (Costanza et al., 2009). Despite this, GDP is continually used to measure well-being all over the world; a purpose for which it was never designed nor intended. GDP was designed to answer questions such as: “how fast is the economy growing,” “what is the pattern of spending on goods and services”, “is economic growth speeding up or slowing down?” GDP can answer these questions quite well. However, problems arise when GDP is used as a method to measure societal well-being, standard of living, quality of life, or even happiness.

By measuring only market activity, GDP ignores changes in the human, natural, and social components of capital that societies depend on in the maintenance and existence of human well-being. Therefore, GDP fails to measure many key aspects which determine the level of societal well-being and in many ways actually encourages behavior that is counter to the long-term well-being of society. GDP measurement is oblivious to the destruction of local economic systems of knowledge, to disappearing forests, wetlands, or farmland; to the depletion of our natural resources; the contamination of groundwater; and to the deaths and displacements resulting from war and natural disasters. It fails to register the costs of pollution or the non-market benefits associated with volunteering, parenting, and very importantly, the ecosystem services provided by nature. It does not capture the dependence of economic activity on the wealth of nature. According to GDP calculations, when used to measure well-being, one billion dollars of war spending contributes to societal well-being equally to one billion dollars spent improving educational institutions or highway infrastructure. It is clear that the latter improves the human

condition, while the former, at best, can be understood as the maintenance of current levels of well-being. This lack of sustainability (in terms of the multiple dimensions of capital) measurement in GDP calculation has led to new areas of inquiry among social scientists attempting to accelerate a transition to an economic system, 'green economy' in some contexts, where progress is measured by real, sustainable improvements in societal well-being rather than simply expansions in the size and scope of market activity. Because GDP measures only monetary transactions related to the production of goods and services, it is based on an incomplete illustration of the system in which humans in the market economy operate. A more complete picture of how the human economic system fits within a much larger system, the social and environmental systems on which it depends, is shown in Figure 2 below.

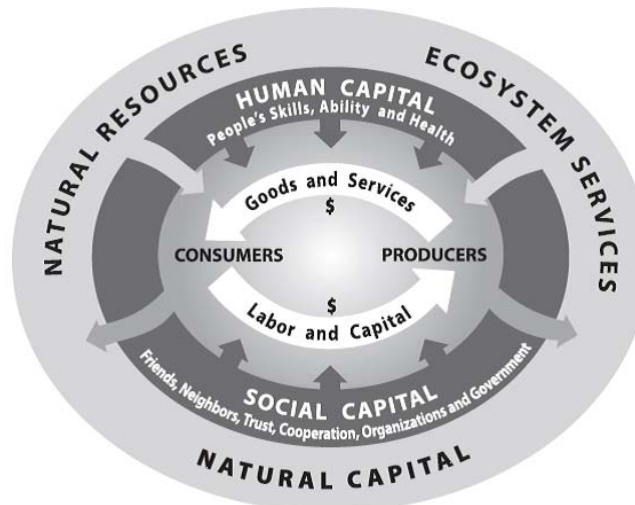


Figure 2: The Economy as Part of a Larger Interdependent System

Source: Costanza et al. (2009)

Figure 2 illustrates that the economy receives benefits from natural, social, and human capital, and the quality and quantity of that capital is affected by levels of net investment in the economy. This system sits within the broader context of nature, biodiversity and ecosystems, which provide the basis for human uses of the earth's wealth as capital. By measuring only marketed economic activity (the inner-circle) GDP ignores changes in the natural, social, and human dimensions of capital which are necessary for our continued existence and the preservation and growth of well-being. In doing so, GDP measurement encourages the depletion of our natural resources faster than they can be renewed, thereby degrading ecosystems and reducing the services they provide to humans. Measurement, monitoring and valuation of these services are difficult, but a true measure of sustainable progress must incorporate some of these important elements.

Measuring the Green Economy

GDP is widely acknowledged to be an insufficient measure of economic development and well-being. Factoring in the importance of environmental and natural resource services is a particularly problematic aspect of traditional economic growth indicators. These limitations have been well documented (see Stiglitz et al., 2009 and Costanza et al., 2009 for examples). Many nations have recognized the importance of measuring the stock and use of their natural resource assets, and have developed sustainable development goals and strategies to reflect these dynamics.

The United Nations Environment Programme (2011) articulated a common vision for a Green Economy that "results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities". Although an agreed and universal definition has not been reached, significant work on the core principles of a green economy has been undertaken. There is general agreement that common green economy principles should include: gender, intergenerational and intercultural equity in access to opportunity for improved

well being; recognition of the dependency of social and economic systems on nature and the diversity of life; recognition that the currently pervasive global political-economic systems and approaches have thus far failed to deliver a just world that values and conserves nature; and recognition that management for improved resilience of ecological systems is essential to link biodiversity and ecosystem services to human well being, and that individual approaches to achieve the transformative changes called for in greening the world economy will vary substantially from case-to-case and context-to-context.

While sustainability has many dimensions, the “green” aspect of measuring sustainability in economic development is the primary focus of this work. This includes issues such as:

- The scope of ecosystem services included in these measures; and,
- Features of the indicators used for measuring the environmental component of sustainable development.

Ecosystem Services Classification

Numerous institutional efforts have shown the importance of including environmental and natural resource productivity measures in indicators of sustainable economic development. For example, as part of the United Nations Conference on Sustainable Development (Rio +20) in 2012, member nations will commit to developing and strengthening their sustainable development measurement/monitoring programs. However, the services provided by the natural environment are complex and heterogeneous. The Millennium Ecosystem Assessment outlined a series of essential services provided by the natural environment for human well-being, and provides a useful classification system for understanding the connection between the macro economy and the environment (MEA, 2005).

Provisioning services refer to the products derived from natural capital and environment assets used directly for economic production and consumption activities. Water, minerals, food, timber, fiber, etc., are all examples of provisioning services that humans extract from the natural environment. Formal markets often exist for such products, allowing for fairly straightforward accounting of the flow of these products in the economy and therefore the value of such services. Combining intertemporal economic valuation methods with measurements of the physical stocks of various provisioning services allows for an accounting of natural capital depreciation and an understanding of the temporal tradeoffs between current and future consumption. Effective sustainable development measurement frameworks should monitor both the flow and stock of provisioning services in the economy. For example, rapidly depleting a stock of mineral or forest reserves may contribute to rapid short-term economic growth (measured as a flow), but the depreciation of this asset for future use would make such a strategy questionable from a sustainable development perspective.

In addition to the direct use of environmental assets for marketable products, ecosystems also provide important **regulating services**. Like provisioning services, these regulating services also provide direct benefits to humans, such as clean air and water, natural disaster and disease control, and productive agricultural systems. While no less important to human well being, these services are often not included in traditional measures of economic well-being or development. Markets for regulating services tend to be lacking as the economic returns for these services often cannot be easily appropriated to a specific individual, making economic signals of scarcity and value either weak or non-existent. Without accounting for such value, there is little economic incentive to invest in the productivity or conservation of these services. Consequently, they will be overused and more rapidly depleted than would be best from a societal perspective. For example, a stable climate provides substantial economic value, but efforts to control the emissions of greenhouse gases have failed in large part due to the lack of strong incentives for emissions reductions. As a result, the benefits of a stable climate are underestimated and inadequately conserved.

Supporting services are those features of an ecosystem that indirectly affect the benefits humans obtain from provisioning and regulating services by increasing or decreasing their productivity. Examples of supporting ecosystem services include:

- Healthy soil formation and nutrient cycling factor into agricultural productivity and erosion control.
- Biodiversity and habitat availability support disease regulation and tourism services.
- Well maintained riparian ecosystems support clean water provision, erosion and flood control, and recreation activities.

Supporting services are perhaps the most difficult to quantify, especially at the scale necessary for national scale sustainable development indicators. In many cases, the quality/availability of these services are determined at a local scale. Efforts to quantify and then value these services are currently underway (see Kareiva et al., 2011); however, the state of the science does not yet permit an adequate methodology for aggregating supporting service values into a national framework.

Cultural services refer to the use of natural environments for “non-material” benefits. Benefits obtained from the direct use of the environment include tourism and recreation. Other spiritual and cultural values may be attributed to the existence of a particular environmental attributes. Where well-functioning markets exist (such as for tourism services), economic values are likely to be incorporated into mainstream economic development measures. However, other services do not have clear market prices representing scarcity and value, which will cause them to be undervalued in national accounts and traditional economic indicators.

While many of the provisioning services are factored into traditional measures of economic progress, excluding the economic value of many regulating and supporting ecosystem services presents an extremely important misrepresentation of economic development and misallocation of scarce and valuable resources.

Important Features of Green Economy Measures

Sustainable development indicators are perhaps as diverse as the development goals they purport to measure. A few key features of the commonly used indicators are outlined below in order to provide an understanding of what the indicators do and do not measure.

A useful measure of the green economy is one which can effectively **aggregate** primary data for a given purpose. Two widely used approaches include the ‘indicator’ approach and the ‘accounting’ approach. The accounting approach integrates environmental and natural resource assets into national statistical frameworks in order to track the stocks and flows of these resources within an economy. While the accounting method does not necessarily require a monetary measure of the environmental assets, the rigorous statistical framework does require environmental accounting to be consistent with traditional economic accounting methods. The indicator approach aggregates primary data into one or more useful measures of a nation's sustainable development objectives. While indicators do not require the statistical and economic rigor of the accounting approach, these indicators are potentially more useful in the policy-making process, as they can provide a concise and consistent measure of progress. Figure 3 provides a schematic overview of these two approaches.

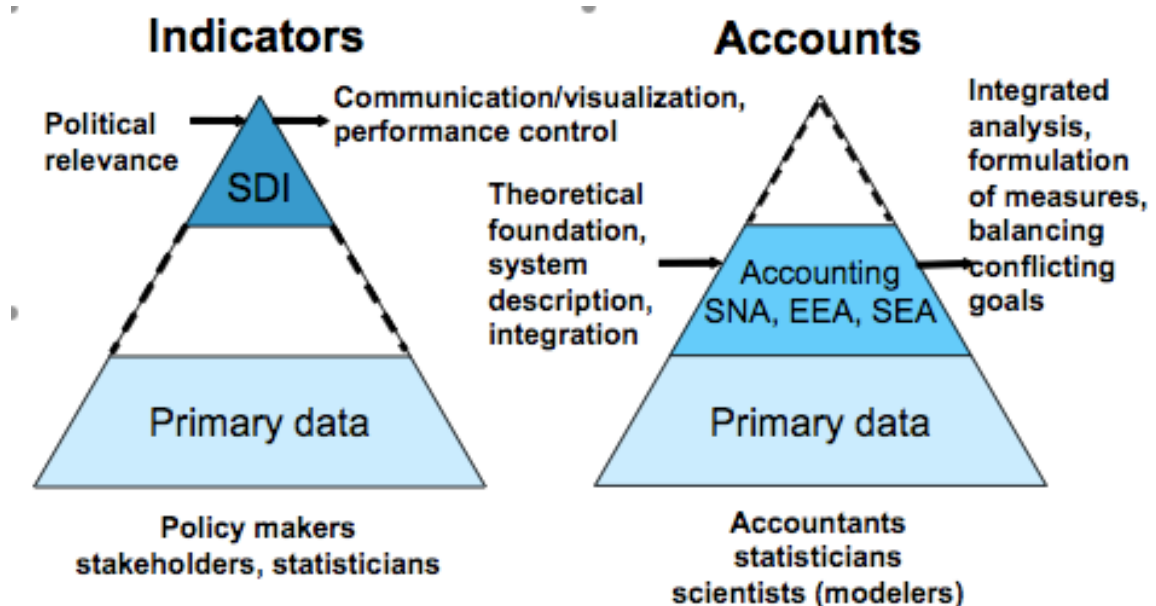


Figure 3: Indicator vs. Accounting Frameworks
Source: Schoer (2006)

The second issue of importance is distinguishing between **stock** vs **flow** measurements. Flows of environmental and natural resource assets in the economy show the current productive uses of these assets. Stock measurements show the availability of these assets for the provision of future services. It is important that nations have measures which reflect the stock of natural capital and the use (flow) of these capital assets for productive activities. Distinguishing between stocks and flows allows nations to begin evaluating tradeoffs between current and future economic opportunities and well-being.

Green economy measurements may be either **physical** or **monetary** in nature. As the name suggests, physical indicators track the physical stock and/or flow of ecosystem services, but do not provide any measure of the economic value of these resources. Monetary indicators on the other hand, translate the physical environmental asset into a specific value, ideally reflecting the marginal value of that asset. When available, prices in well-functioning markets provide one measure of the marginal value of an ecosystem service and can be used to compute monetary indicators. However, for many ecosystem services, especially regulating and provisioning services, markets do not exist. Economic tools involving the non-market valuation of these assets is required in order to create a monetary indicator. The monetary valuation of ecosystem services is a rapidly developing field of economic inquiry. Monetary indicators are required for an economic integration of ecosystem services into traditional measures of economic progress. This integration allows for policymakers to assess tradeoffs between different types of capital assets, consistent with the concept of weak sustainability.

Review of Sustainable Development Indicators

Category 1: Accounting Frameworks

While accounting frameworks are technically not classified as indicators, the approach is extremely important for developing quality measures of sustainable economic development. Environmental-economic accounting uses a systems approach to measuring ecosystem services, requiring that stocks and flows of environmental assets be tracked using a consistent statistical framework. Accounting frameworks that incorporate environmental assets is often referred to as "Green Accounting" or "Green GDP," and in the context of this report, refers to integrating ecosystem services into national accounting methodologies.

UN System of Environmental-Economic Accounts

The United Nations System of Environmental-Economic Accounts (SEEA) is a program developed to assist national statistical agencies in incorporating environmental and natural resource assets into formal System of National Accounts (SNA) measurements (United Nations, 2012). The original draft of the SEEA methodology provided guidance for measuring and integrating:

- Physical flows of environmental and natural resource assets produced and consumed in the formal economy;
- Expenditures on environmental protection; and
- Natural resource stocks not yet used for formal production and consumption activities.

Three 'sub-systems' of the SEEA are currently under development to improve upon the scope of the original methodology. Water and Energy sub-systems are being developed to track physical flows of these two resources in the economy. The water sub-system measures the use of water in the economy and the impact of economic activity on a nation's water supply. Both water quality and quantity are incorporated into the national accounts. The energy 'sub-system' tracks the energy use and subsequent byproducts in an economy, providing an essential foundation for integrating energy-related emissions damages into traditional economic indicators. An experimental Land and Ecosystem sub-system is currently being developed by the World Bank through the Wealth Accounting and the Valuation of Ecosystem Services (WAVES) project, which incorporates available provisioning ecosystem services (biomass/carbon and water) and several regulating and cultural ecosystem services. This sub-system is under development and experimental accounts are being constructed for a select group of developing nations (World Bank, 2011). Developing this sub-system will be an important contribution to the SEEA framework.

Because the SEEA are designed to be integrated into SNA's, they represent a gold standard in environmental accounting, and can therefore be considered a strong base for developing more accurate indicators of sustainable economic development. However, the SEEA is limited by the scope and quality of environmental and natural resource data. This has proven to be a formidable obstacle for many developing nations with underdeveloped environmental monitoring infrastructure.

There have been a number of applications of the SEEA methodology for policy analysis, and several national statistical agencies collect and compile the required data. Several examples of SEEA (or closely related) applications include:

- Health Damages from Air Pollution in the U.S. and China: Muller et al. (2011) and Hon and Jorgenson (2007)
- EU Land Cover, Wetlands, and Natural Grassland Accounts: European Environmental Agency (2011)
- Wealth Accounting and the Valuation of Ecosystem Services (WAVES) Pilot Program for Botswana, Colombia, Costa Rica, India, Madagascar, and the Philippines: World Bank (2011)

Genuine Progress Indicator

The Index of Sustainable Welfare (ISEW), which has since been revised and renamed the Genuine Progress Indicator (GPI), was first proposed in the 1989 book, *For the Common Good*, by Herman Daly and John Cobb. The goal was to develop an index that accounted for both current environmental issues and long-term use of natural ecosystems and resources. In 1995, a group called Redefining Progress issued a revised methodology and changed the name to its current form (Talberth et al., 2007). The GPI is designed to measure the sustainability of current national income by distinguishing between economic transactions that are welfare-enhancing from those that are well-being and sustainability reducing.

GPI attempts to correct the deficiencies in GDP accounting. Computation begins with personal consumption expenditures, weighted by income inequality, to reflect the social costs of inequality and the diminishing returns to income received by the wealthy. Additions are then made to account for many non-markets benefits such as: the value of housework and parenting, higher education, and volunteer work; and the services provided by consumer durables (household capital) and infrastructure. Deductions are made to account for defensive environmental protection expenditures (costs of pollution control) and the costs reflecting the negative externalities associated with economic growth. These include the cost of crime, underemployment, consumer durable purchases, commuting, household pollution abatement, automobile accidents, water pollution, air pollution, noise pollution, and ozone depletion; the loss of leisure time, wetlands, farmland, primary forests and logging roads; the depletion of non-renewable resources; carbon emissions damage; and net foreign borrowing.

The GPI has strong roots in economic theory and national income accounting, as well as incorporating widely shared principles of sustainable development. Criticisms have emerged in terms of its theoretical foundations, components, and calculation methods. Dietz and Nuemayer (2006) argue that it is impossible to combine an indicator of current well-being with one of future sustainability, emphasizing that the impact of the depletion of natural resources on future generations should not affect current levels of well-being. The most common criticism is the seemingly arbitrary selection of components to be included in the index and the use of non-market valuation to assign monetary values to many of the components. Thus far, GPI data is available only for the United States from 1950 to 2004 and a few other OECD countries. The difficulty in obtaining data and valuations that could be standardized and disseminated internationally in an evolving global economy makes the GPI an unlikely solution for measuring real sustainable progress. However, its foundations in national income accounting lend itself toward potential expansion in the future.

Genuine Savings

Adjusted Net Savings (ANS), more commonly known as Genuine Savings (GS), was developed for the World Bank and is defined as “the true level of savings in a country after depreciation of produced capital; investments in human capital (as measured by education expenditures); depletion of minerals, energy, and forests; and damages from local and global air pollutants are taken into account” (Hamilton et al., 2006). The national income accounts are the foundation for GS, as with the GPI. In standard national accounting only the formation of produced capital is counted as an investment in the future and standard calculations of net savings rates include only the depreciation of physical man-made capital as a reduction in the stock of capital assets in the economy. GS takes a broader view that both natural and human capital are assets vital to the well-being of society.

Genuine Savings relies on the concept of “weak-sustainability”, also known as the Hartwick-Solow rule, that any type of capital is perfectly substitutable for natural capital as an input in production (Bolt et al., 2002). The limitations and validity of this assumption is the topic of much controversy, as it implies that, at the extreme, if a country reinvests all of its profits from the exploitation of the natural environment into the education of its citizens (human capital) there will be no net opportunity costs imposed on future generations. More usefully, the use of nonrenewable resources can be viewed as sustainable if it results in greater opportunity for future generations. However, putting the validity of the assumption aside, the GS methodology provides policymakers with a preliminary framework for evaluating their success in committing to a sustainable future.

Dashboard Indicators

Dashboards refer to a suite of indicators that can be used to measure the progress towards a defined set of development objectives. They are designed to provide a more comprehensive picture than a single index/indicator of a nation's current development status. Dashboard

indicators do not usually follow the statistical rigour of an accounting framework and in many ways have greater flexibility in describing progress toward development objectives.

Calvert-Henderson Quality of Life Indicators

The Calvert-Henderson Quality of Life indicators include twelve categories of indicators measuring a variety of aspects of economic well-being, developed by the Calvert Group, a private asset management firm (Flynn et al., 2000). The indicators were originally compiled in 2000 (with periodic updates) primarily using publicly available national statistics for the United States.

In addition to measures of education, employment, health, human rights, income, infrastructure, national security, public safety, recreation, and shelter, the C-H indicators also include two environment and energy categories, which are meant to capture sustainable economic development in the United States. The environment indicators highlight trends in air and water quality, while the energy indicators report the efficiency of energy use in the U.S. economy. These indicators do not generally incorporate economic valuation methods, making standardization and comparison to other indicators difficult.

EU Sustainable Development Indicators

The EU Sustainable Development Indicators (SDI) were developed in response to commitments made at the 1992 Earth Summit in Rio de Janeiro. The suite of indicators is designed to provide a detailed account of whether the EU is meeting its sustainable development objectives. Over 100 indicators have been developed (or are under development) for all EU member countries from 1990-2010 (subject to data availability) across a variety of economic, social, environmental, and governance themes (European Commission, 2012).

The SDI includes both environmental and natural resource 'themes.' The environmental indicators focus entirely on greenhouse gas emissions and energy production and consumption by generation source. The natural resource theme uses population counts of important bird and fish species as headline indicators to proxy biodiversity and ecosystem health. This theme also includes indicators for freshwater availability and land use change. A third relevant theme, sustainable production and consumption, includes measures of hazardous air emissions and other toxic chemicals.

As with other 'dashboard' indicator suites, integrating the SDI with traditional economic performance metrics presents a challenge. For example, the environmental and natural resource indicators do not include any economic valuations, nor do they track the flows of the natural capital assets in the formal economy. However, the SDI is amenable for comparison with formal development goals such as the Millennium Development Goals and the Human Development Index.

Composite Indicators

Composite indicators refer to the aggregation of other indicators/indices/data sources into a single measure of progress toward a defined objective. A highly aggregated single indicator is appealing for policy-making due to the fact that it is simple to understand and tells a concise narrative. However, composite indicators are most often not constructed using economic valuation techniques, making it difficult to assess tradeoffs. Furthermore, the weights given to various elements of the composite index are often based on normative judgments creating inconsistency between other measures of a similar development objective. Nevertheless, composite indicators are widely used in developing policy, and the quality construction of such indicators is an active area of academic research.

Human Development Index

Since 1990, the United Nations Development Program (UNDP) has used the Human Development Index (HDI) in its annual Human Development Report (United Nations, 2010). The HDI is a composite index used to rank and compare countries in terms of three components of

economic and social well-being: longevity (health), knowledge (education), and access to a decent standard of living. Longevity is measured using life expectancy at birth. The education component of the HDI is measured by the average years of schooling for adults aged 25 years and expected years of schooling for children of school entering age. Access to a decent standard of living is measured using purchasing power parity adjusted gross national income (GNI) per capita. The HDI uses the logarithm of national income to incorporate the concept of the threshold effect, or the diminishing importance of income as GNI increases. The use of readily available data allows for the reporting of HDI rankings for nearly all the countries of the world (187 countries in the 2010 report).

The two main criticisms of the HDI is its lack of inequality and ecological measures. In order to address the first concern, the United Nations has newly developed the inequality-adjusted HDI (IHDI) for the 2010 report. Under perfect equality the IHDI is equal to the HDI, but falls below HDI when inequality increases. The IHDI accounts for inequality in HDI components by “discounting” each component’s average value according to its level of inequality measured by the Atkinson index. The United Nations has thus far applied this index to 134 countries. However, the lack of any environmental, natural resource, or ecosystem related accounting makes even the IDHI unsuitable as a measure of sustainability, but an extremely useful index for use in the comparison of current levels of economic and social well-being (in its limited context) across countries.

Environmental Sustainability Index

Since the early 2000s researchers from Yale and Columbia University have been working to develop an index that measures the ability of nations to protect the environment over the coming decades. The ESI integrates 76 data sets -- tracking endowments of natural resources, current and past pollution levels, and environmental management efforts -- into 21 indicators of environmental sustainability that fall into 5 broad categories: environmental systems, reducing environmental stresses, reducing human vulnerability to environmental stresses, societal and institutional capacity to respond to environmental challenges, and global stewardship (Esty et al., 2005).

The data sets are integrated into 21 indicators and placed into the 5 broad categories as follows:

Environmental Systems

- Air Quality
- Biodiversity
- Water Quality
- Water Quantity
- Land

Reducing Environment Stresses

- Reducing Air Pollution
- Reducing Ecosystem Stress
- Reducing Water Stress
- Natural Resource Management
- Reducing Waste and Consumption Pressures

Reducing Human Vulnerability

- Environmental Health
- Basic Human Sustenance
- Reducing Environment-Related Natural Disaster Vulnerability

Social and Institutional Capacity

- Environmental Governance
- Eco-efficiency

- Private Sector Responsiveness
- Science and Technology

Global Stewardship

- Participation in International Collaborative Efforts
- Greenhouse Gas Emissions
- Reducing Transboundary Environmental Pressures

Ecological Footprint

The Ecological Footprint (EF) was designed and developed by Mathis Wackernagel and William Rees as a way to account for flows of energy and matter into and out of the formal economy and convert those flows into a measure of the area of productive land and water required to support those flows (Costanza et al., 2009; Wackernagel and Rees, 1996). The EF is intended to be used as a resource management tool to determine whether an individual, city, or nation is depleting the natural environment more quickly than the existing ecosystems can regenerate that natural capital.

The Global Footprint Network calculates the Ecological Footprint (the demand on nature), and biocapacity (the ability to meet this demand) of more than 200 countries, territories, and regions. The EF uses yields of primary products to calculate the area necessary to support a given activity. Biocapacity is measured by calculating the amount of biologically productive land and sea area available to provide the resources a population consumes and to absorb its wastes, given current technology and management practices (Global Footprint Network, 2011). The results in the National Footprint Accounts, therefore, identify whether or not a nation's Ecological Footprint exceeds its biocapacity; in which case that country is running an ecological deficit. The global ecological deficit is also known as ecological overshoot (Ewing et al., 2010).

These biocapacity and Ecological Footprint indicators focus on the bio-mass based flows of the ecosystem's provisioning services and the waste uptake of its regulating services (Ewing et al., 2010). The National Footprint Accounts can therefore provide policymakers with information regarding the sustainability of their economy relative to the ecosystems that must support that growth.

Living Planet Index

The Living Planet Index is a widely used composite indicator published by WWF International aimed at measuring global biodiversity. The index aggregates populations for over 2,500 vertebrate species to gauge the health of the earth's ecosystems. The LPI is constructed using species populations in various biomes and geographic realms (rather than national boundaries), although data quality and geographic scope varies considerably. The LPI is a time series index available from 1970-2007 (Loh et al., 2005).

Although adjustments for 'overrepresented' species are made, the LPI gives equal weight to all species and all ecosystems. The index does not incorporate any economic valuation techniques for biodiversity and ecosystem services, and should therefore be viewed only as a physical indicator of ecosystem health and the world's biodiversity stock. According to WWF, valuation exercises are currently underway, although details are limited. The LPI is a useful tool for measuring biodiversity and can be combined with other indicators, such as the Ecological and Water Footprints, to develop an overview of the demand for and supply of various ecosystem services.

Figure 4 compares the eight indicators described above (in addition to GDP) using the ecosystem service classification described in Section II as well as the other important indicator features. Dark red implies that the indicator does not measure the stated category, while dark green indicates that the ecosystem service is measured quite well. Lighter red/green shades indicate some intermediate inclusion of the service.

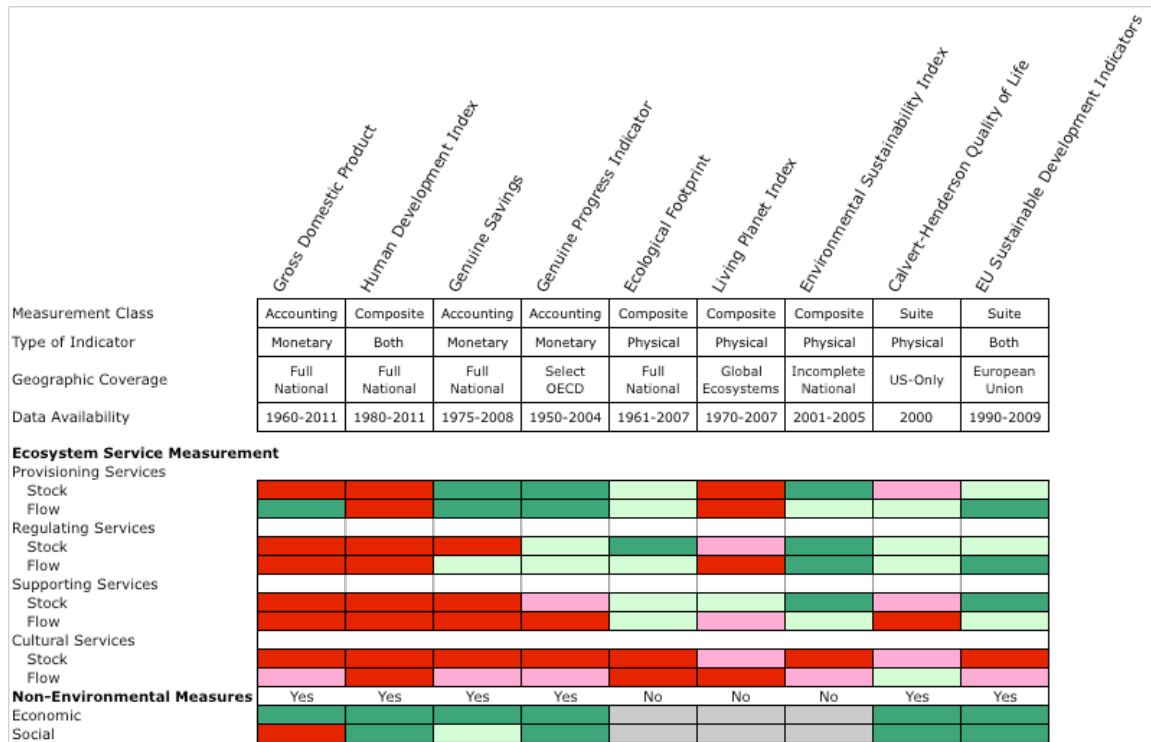


Figure 4: Commonly Used Measures of Sustainable Development: Boxes shaded in dark red imply the indicator does not include the specific measure. Boxes shaded in dark green imply the indicator explicitly includes the specific measure. Lighter shades of red/green are used for intermediate quality measures of the indicator.

IV Indicator Comparisons

The degree to which existing indicators can incorporate ecosystem services, as represented in Figure 4 is limited by data availability and environmental valuation. For purposes of discussion and understanding a subset of 20 selected nations are illustrated according to various indicator rankings among 108 nations in Figure 5. Each colored bar in the figure represents the relative ranking of 108 nations, with the top of the bar denoting a rank of one (the "best") and the bottom of the bar denoting a rank of 108 (the "worst"). The 20 nations are listed on the left of the figure according to their rank among these 108 nations in 2007 GDP per capita (left-most bar) measured in 2005 purchasing power parity adjusted US dollars. One may then proceed to trace the relative ranking of any country among these five indicators by following the dotted line across the diagram. The second bar shows the relative rankings according to the 2005 Human Development Index (HDI). The third bar shows the relative rankings according to 2007 Genuine Savings (GS) or Adjusted Net Savings (ANS) calculations, measured as a percent of the Gross National Income (GNI) of that nation. The fourth bar shows the relative rankings according to the 2007 National Footprint Accounts. These rankings are based on the level of ecological reserve, defined as the difference between a nation's ecological footprint (EF) and its biocapacity. The nation with the highest ecological reserve receives a relative rank of one. Finally, the fifth bar shows the relative rankings according to the 2005 Environmental Sustainability Index (ESI), and the nations are listed again on the right side of the figure according to their relative ESI rankings.

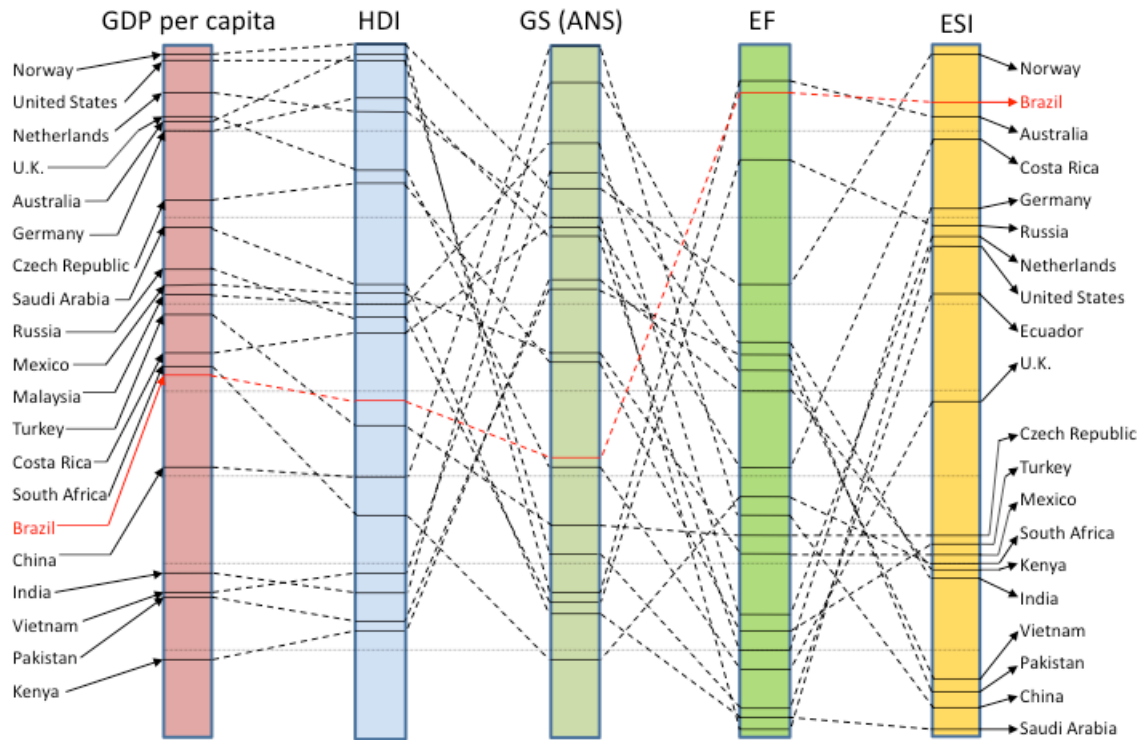


Figure 5: Relative Indicator Rankings Among Selected Nations

For illustration purposes, trace the relative rankings of Brazil in order to develop an understanding of the usefulness of Figure 5. In 2007, Brazil had a GDP per capita of \$9,196, placing them at a rank of 53 out of 108. Their HDI score was 0.692 in 2005, placing them at a rank of 55 out of 108. In general, this is common; nations remain fairly stable in rankings according to HDI, since national income per capita is itself a component of HDI. Following the red dotted line, one can see that Brazil drops to a rank of 65 for GS (ANS). In general, one would expect middle-income, fast-growth nations to perform fairly well in GS due to outsourcing of natural capital depreciation or accelerating growth in other forms of capital. Continuing with our discussion of Brazil, their ecological reserve ranking is 7 out of 108, an obvious result of their large natural resource stocks and moderate levels of depletion. Lastly, Brazil ranks 9 in ESI, again reflecting high levels of biocapacity and moderate levels of stewardship. The relationship between economic progress and environmental stewardship depends on a variety of elements defining a nation's profile in terms of development, growth, resource stocks, etc. (Esty et al., 2005).

Of further interest is comparing the growth rates of various indicators for a few select nations. Is there is correlation between the growth rates of GS and HDI or GDP per capita? To the extent that GS measures some aspects of weak sustainability (or a nation's stock of physical, human, and natural capital); high levels of GS should tend to promote growth and development. Figure 6 displays the growth rates of GDP per capita, GS (ANS), and HDI for five selected nations and highlights the difficulties of using indicators based on the concept of weak sustainability to assess overall environmental sustainability.

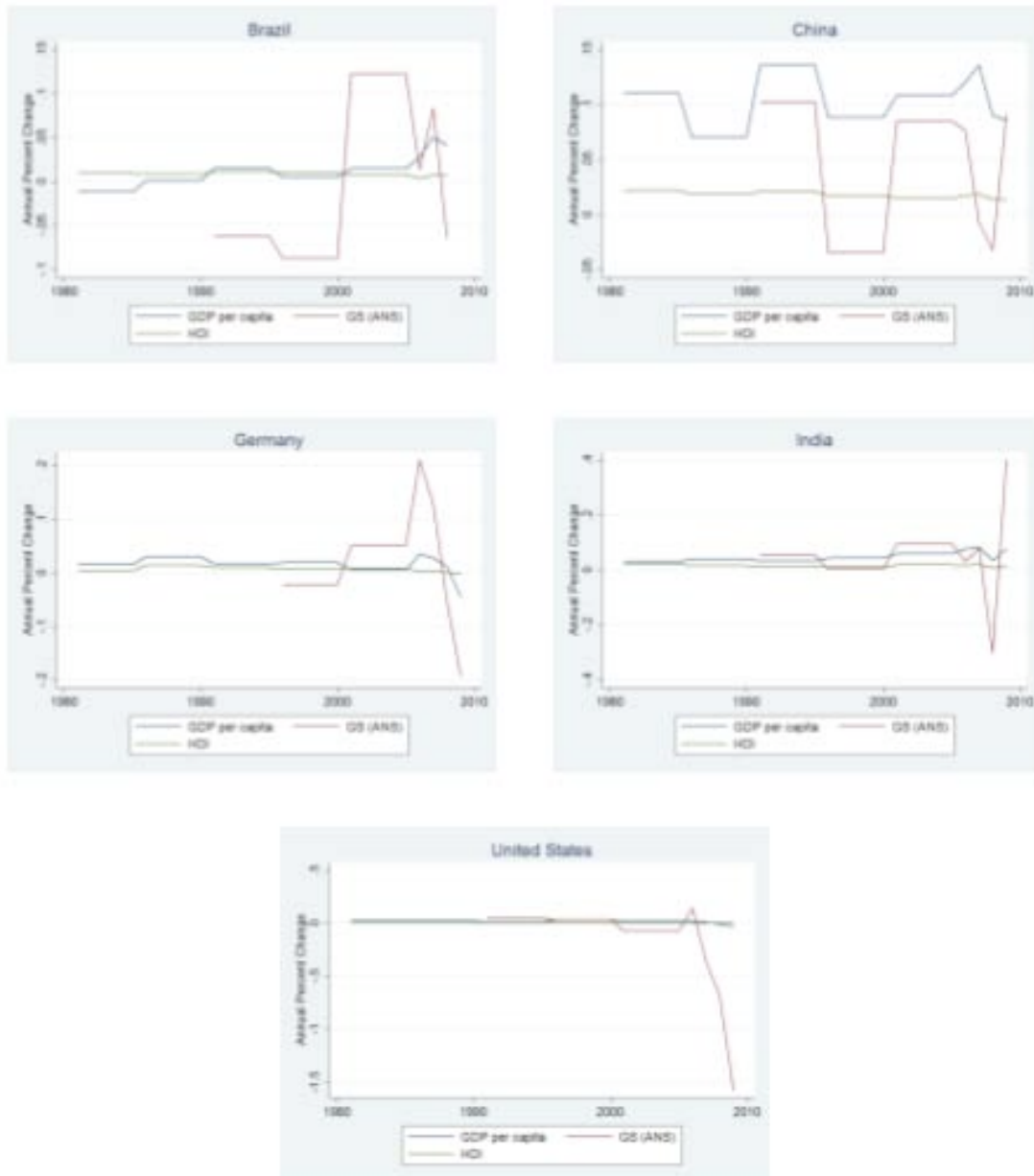


Figure 6: Indicator Growth Rates for Selected Nations

Notice in Figure 6 that GS is much more volatile than both GDP per capita and HDI which makes it somewhat difficult to ascertain the level of correlation between the three indicators. However, we do see pro-cyclical elements in GS, meaning higher levels of GS during periods of economic growth. What GS fails to illuminate are the tradeoffs among alternative forms of capital. If GS is growing at a rapid rate, as is generally the case with China, we cannot determine whether this increase in GS is due to decreases in the rate of natural capital depletion or increases in the growth of human and physical capital investment. Furthermore, this highlights the importance of sustainable welfare indicators, specifically those targeted at measurement of the natural environment that are independent of human and physical capital accumulation. Section V will summarize these continued barriers in the development of alternative measures of sustainability and welfare and highlight some important policy recommendations.

V. Discussion

Assessing sustainability requires many assumptions and normative choices and is further complicated by the interaction with the heterogeneous socio-economic and environmental climates of different nations. While a comprehensive assessment of sustainability is difficult to establish, there have been significant attempts to provide recommendations to policymakers. Here we will briefly summarize some of the prevailing recommendations.

While the question of sustainability is complementary to the question of current well-being, based on currently available metrics, the two should be measured independently. The most confusion arises when indicators of sustainability are aggregated together with traditional indicators of economic progress, as is the case with Genuine Savings mentioned in Section IV. To take an analogy, “when driving a car, a meter that weighed up in one single value the current speed of the vehicle and the remaining level of gasoline would not be of any help to the driver. Both pieces of information are critical and need to be displayed in distinct, clearly visible areas of the dashboard” (Stiglitz et al., 2009).

In order to measure sustainability and the green economy indicators should be used that provide information on the direction of growth along the various dimensions that contribute to future well-being. Understanding sustainability in this manner mandates the simultaneous preservation or growth of various stocks, both in terms of quantity and quality; and across all forms relevant to future well-being: physical, human, social, and natural capital. This approach avoids one of the most criticized elements of GDP, the supposed “rewards” for environmental disasters/depletion; via the economic activity generated by repairs and restoration.

A monetary index of sustainability has its place in the discussion. However, given the current state of the art, monetizing stocks and flows of certain ecosystem services entails the use of uncertain non-market valuation methods. From an economic perspective, monetization is appealing, because it allows for policymakers to make tradeoffs across capital stocks (ie, weak sustainability decisions). However, if the valuation exercises are flawed, these tradeoffs are not reflecting the true value of the various capital assets (namely, the natural capital). The precautionary principle applies here; if we are relying on non-existent or weak price signals to determine the degree to which stocks of these assets contribute to future well-being, then tracking changes in these capital stocks independently preserves the notion of strong sustainability without the requirement of one monetary indicator which raises both normative and informational difficulties. If a single monetary indicator can only provide imprecise estimates of natural capital substitutability then the precautionary principle would tell us to opt for higher quality, non-monetary physical indicators. This approach is consistent with the concept of strong sustainability, and better reflects the lack of certainty in intergenerational capital stock substitutability. Efforts to place economic value on environmental damages should, by no means, be reduced; however, given the current state of the art, the precautionary principle encourages continued research. Also, given the global public good nature of many environmental issues, such as climate change, incorporation of these damages into any one nation's sustainability indicator would be a gross oversimplification. In general, it is best to establish what can be measured, and proceed to use/develop a dashboard of physical indicators consistent with the best available science.

The Commission on the Measurement of Economic Performance and Social Progress, chaired by Joseph Stiglitz, Amartya Sen, and Jean-Paul Fitoussi recommends a small dashboard of physical indicators, founded in the stock approach to sustainability which would combine “an indicator more or less derived from the extended wealth approach, “greened” as far as possible on the basis of currently available knowledge, but whose main function, however, would be to send warning messages concerning “economic non-sustainability” and a “set of well-chosen physical indicators, which would focus on dimensions of environmental sustainability that are either

already important or could become so in the future, and that remain difficult to capture in monetary terms" (Stiglitz et al., 2009).

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