Can Indicators and Accounts Really Measure Sustainability?
Considerations for the U.S. Environmental Protection Agency

Joy E. Hecht, Ph.D.
Consultant on Environmental Economics and Policy
jhecht@alum.mit.edu

Throughout the world, sustainability has become the common term of art for describing the objectives of public policy. At the same time sustainability indicators have become a preferred tool for tracking the actions of public agencies at the global, national, state or provincial, and municipal levels. Some public agencies have developed elaborate systems of sustainability indicators with which they hope to track their progress. Other have adopted, and adapted to their own needs, international indicator systems and indices[1] developed by global organizations such as the United Nations and the World Bank.

The U.S. Environmental Protection Agency (EPA) is considering following this path, and adopting sustainability as a benchmark for its own work and using sustainability indicators to assess the agency's progress. But before it takes this step, it is essential to consider what these indicator systems actually tell us about sustainability. When these indicators move in the "right" direction – if we even know what that is – does that really mean that our economy, our environment or our society is actually sustainable? Do we know how to define sustainability precisely enough to use it as a basis for assessing public policy decisions? And will such indicators enable the agency to show measurable results from its actions, as it is increasingly under pressure to do, along with all U.S. government agencies?

This paper considers some of these questions in order to help EPA to consider how – or whether – it can effectively rely on sustainability indicators to define its objectives or measure its progress. To do so, it presents an overview of some of the systems that have been developed to construct simple indicators or indices of sustainability, and assesses the extent to which they may be useful to EPA.

What Do We Mean by "Sustainability?"

Since it came into common parlance after the Rio conference in 1992, the word "sustainability" has been used to describe everything from keeping our air and water clean, to finding new economic activity for towns whose old industries are gone, to ensuring that people in small African villages can retain their traditional way of life. We hear of the three "pillars" of sustainability – economic, environmental, and social – and the need for all of them to be sustainable in order for the system as a whole to be sustainable.

---

[1] For the purpose of this article the word "indicator" refers to a simple measure of a single parameter, and "index" refers to a measure that combines a number of parameters into a single value using some mathematical formula to do so, except in the case of the Genuine Progress Indicator.

What does this have to do with the meaning of the word "sustainable" in ordinary English, before it became a term of art? The American Heritage dictionary offers nine definitions of the verb "to sustain," of which the most relevant is "to keep in existence." So something that is sustainable is something that can be kept in existence – presumably more or less independently, without continuous infusion of outside support or influence. A sustainable society, then, might be one that will continue to exist in its current form. While the dictionary wasn't written with late twentieth century environmental politics in mind, it nevertheless offers a useful starting point.

This has a reasonably clear interpretation in the field of economics. A sustainable economy is one in which the ability to generate income is maintained. This usually implies that assets retain their value, because income is the payment made in return for use of an asset.

Sustainability also seems to have a reasonably clear meaning in biology – though natural scientists might consider that a glib assessment on the part of a social scientist! An ecosystem might be considered sustainable if at some level the species within it continue to exist and interact with each other, with only gradual evolution of species or the niches they occupy. A population might be considered sustainable if it can continue to exist within its ecosystem at reasonably uniform levels over time. From a human perspective, we might consider an ecosystem sustainable if we are sure it will continue providing us with services such as clean water and air, food, watershed protection, or carbon sequestration.

In some respects, social sustainability can be understood in an analogous way. If our consumption patterns cause people to become ill, due to pollution or unhealthy food for example, then the social system cannot be considered sustainable because it doesn't allow people to survive. If our technology and consumption patterns rapidly deplete the ecosystems on which we depend and we cannot develop alternatives, they are unsustainable. If our social system leads to great dissent and people kill each other off, for that matter, it could not be considered sustainable.

Other aspects of social sustainability are harder to fit into this concept, however. Some sustainability advocates understand the concept to mean that communities may continue to operate as they have in "the past" (an undefined time span, but that isn't important for our purposes). This might mean that the social structure of an African or Amazon village is unchanged; they are not affected by the impacts of other societies (negative, such as pollution, or enticing, such as television); and they are not forced by the failure of the traditional economic system to leave the village and move to the city. It can mean that the residents of company towns where the company leaves – mining towns, for example – will find another way to survive economically as a community, rather than dispersing as young people move elsewhere in search of work. While this interpretation of social sustainability has some appeal, it is hard to reconcile with the fact that these social changes may be considered desirable by the residents of the communities involved. Life in an African village is very hard; people moving to the city may do so for an easier life, not because they are pushed out by the failure of their economic system. While some youngsters in rural America might like to live their lives as their parents did, others are eager to get a broader perspective on the world and consider other ways to make living. Freedom of choice may not be compatible with social sustainability in these cases.

Many sustainability advocates argue that to be sustainable, a society must be equitable, participatory, and democratic. But inequitable and dictatorial societies have been sustained very effectively for millennia; this concept of social sustainability fails the dictionary test. Instead, an alternate concept may be useful. Whereas there is an intrinsic meaning to "sustainability" in economics and nature that we can't override, in social terms the kinds of societies that have been sustained in the past may not be the ones we *want* to live in. So the third pillar of sustainability could involve deciding what we want to sustain – values such as equity, participation, and democracy – and searching for a way to achieve these in a system that is economically and biologically sustainable.

Another approach to social sustainability might mean that our social practices – consumption, technology, food and transportation choices, recreation – can be sustained in environmental and economic terms. This does not mean that we can maintain any practices we like. Instead, it suggests that if we wish our society to be sustainable, we may have to adapt our practices so that we are economically viable and do not destroy the resources on which we depend. This approach to social sustainability is illustrated by Jared Diamond's work on why societies collapse,[2] in which he discusses how some societies destroyed their own resource bases and committed "social suicide," while others were willing to adapt their consumption patterns or cultural norms in order to survive environmentally and economically.

The Whole is Greater than the Sum of its Parts

The value added of the concept of sustainability, above and beyond the social, economic, and environmental concerns that make it up, is that it forces us to recognize links and trade-offs, rather than dealing with each concern independently. To achieve sustainability, we need to sustain our economy, protect our environment, *and* achieve our social goals – ideally without trading off one goal for another.

Sustainability is a valuable concept precisely because it does require us to focus on the integration of social, economic, and environmental concerns. However, like "holistic thinking," which it resembles, this is much easier said than done. Identifying economic, environmental, and perhaps even social implications of marginal changes is easy. For example, it is relatively straightforward to observe the impacts of an increase in gasoline prices on miles driven, greenhouse gas emissions, how people organize everyday activities requiring travel, and demand for gas-guzzling support utility vehicles.

But how could we quantify the changes involved in movement to a higher-density urban form that does not require use of cars and reduces impervious surface in roads, but has people living in high-rise buildings that cost more per square foot than single-family homes and requires energy consumption and safety considerations not needed in the old housing forms? If most Americans prefer single-family homes with large lawns, and enjoy the luxury of a private car, would living at greater density be socially acceptable? Would it be consistent with a concept of social sustainability that includes the idea of allowing communities to continue to operate as they have "traditionally," or at least as many people wish to continue living? Is it even possible to

[2] Diamond 2005.

identify all of the complex tradeoffs involved in a shift from suburban sprawl to dense urban living in terms of impacts on economic, environmental, and social sustainability? All of these analyses would be merely a starting point for evaluating how a modern community in the United States could be sustainable, and they are clearly both complex and difficult.

Sustainability Indicator Systems

This brings us back to the problem of measuring and tracking sustainability using indicators that might be able to simplify the problem. Sustainability indicator systems have been developed at all levels of government, and throughout the world. In the United States, states from New Jersey to Oregon and municipalities from Seattle, Washington to Jacksonville, Florida, have developed sets of indicators with which they hope to measure their progress. Internationally, organizations including the United Nations, the European Union, and a number of other regional groups have developed sustainability indicators system that they recommend to their members.

Most of these sustainability indicator systems track progress within the economic, environmental, and social arenas separately. The UN system, which is something like the "mother of all indicator systems," tracks fifty eight separate parameters.[3] Its social indicators provide information on life span, nutritional status, education, population, and child mortality. The environmental indicators look at ambient air and water quality, greenhouse gas emissions, land use and land cover, and species diversity. The economic indicators include conventional measures such as GDP per capita, as well as measures of consumption and saving.

Clearly these indicators cover a range of issues that we care about. However, they don't tell us much about *sustainability* – as opposed to environmental quality, public health, or economic well-being. If the value added from thinking in terms of sustainability is that it forces us to be holistic, how can our indicators do the same? The UN sustainability indicator system, while both useful and influential, does not do this. Moreover, even within the three arenas, most of the UN indicators tell us where we stand now but do not tell us whether our current position can be sustained in the future.

Sustainability Measures within a Single Arena

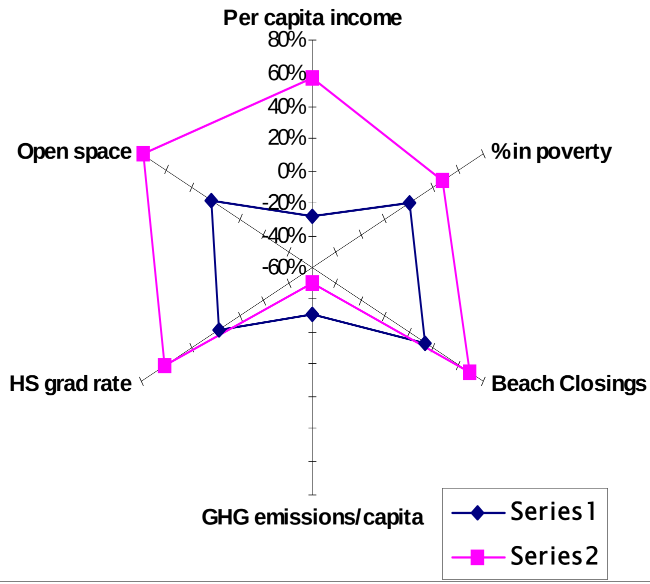
Sometimes a single measure, within one of the three arenas of sustainability, can by itself tell us something about whether our system is sustainable. Among environmental indicators, air quality is one such measure. If we know the ambient concentration of air pollutant that is safe to breathe, any observation above that level must be unsustainable, because it will lead to illness. This single indicator only addresses environmental health, however, so it is a very partial measure of sustainability. Moreover, if we exceed the standard, we know we are *not* sustainable, but if we fall within it, we don't know that we *are* sustainable. Similarly, in the economic arena, if savings (in financial terms or more broadly including natural and human capital) are negative, we can assume that our system is not sustainable. If savings are positive, though, we don't know whether other features of our economic system may nevertheless make it unsustainable. This is a

[3] Details are available at http://www.un.org/esa/sustdev/natlinfo/indicators/isd.htm.

common quality of sustainability indicators; it can be easy to determine that we are not sustainable, but very hard to determine that we are.

Indicator Suites

To emphasize the importance of making progress on all of the key indicators together, some systems organize them into a simple "suite" of measures, in which all must move in the right direction at once. If any one value lags behind, the whole system is considered unsustainable.



If there are only a few key indicators, they are sometimes presented in a visual form like the diagram below. This graphic, called a "radar chart" in Excel, provides data on six indicators at two points in time (series 1 and series 2). The darker colored inner polygon on the chart shows the first data point and the lighter colored outer ones show the second. If an indicator improves over time, it moves outwards on the chart; if it becomes worse it moves in. Thus if progress is being made over time the later polygon will enclose the earlier one, but if one indicator lags, as do GHG emissions in this example, then the two polygons will overlap.

A graphic like this can give a quick visual check of whether the overall system is becoming better or worse. If we had a longer time series than two points, however, this kind of graphic would become impossible to follow visually. Moreover, this approach to defining sustainability does not allow for tradeoffs among the indicators, or for patterns in which an increase in one indicator is consistently associated with a decrease in another. It is useful only for a simple snapshot of a small set of indicators over two time periods.

Environmental Accounting and "Green GDP"

Many systems for tracking sustainability have gone beyond simple indicators to build full sets of accounts, national indices, or both. One of the best known accounting systems is the environmental accounts, more formally referred to as the System of Integrated Economic and Environmental Accounting, or SEEA.[4] It builds on the System of National Accounts (SNA, or national income accounts) to integrate the data with information on the environmental impacts and dimensions of the economy.[5] The development of environmental accounts arose for a

[4] For the full technical reference on the SEEA system, see UN et al, 2003. For a non-accountant's introduction to environmental accounting and the SEEA, see Hecht, 2005.
[5] The national accounts are the national economic data systems used to calculate familiar macroeconomic indicators such as Gross National Product and Gross Domestic Product (GNP and GDP, respectively).

number of reasons, among them the recognition that the SNA did not capture the environmental externalities of economic activity, nor did it capture changes in natural or human capital.

The SEEA is an accounting framework, whose primary purpose is to provide a framework for integrating data on the environment with the economic data in the national accounts. Like the SNA, the SEEA has been designed through the coordination of the United Nations Statistics Division, so it is the closest thing to an official system for linking environmental and economic data. Parts of the system are being implemented in most OECD countries (the United States being the notable exception), and work is underway in several dozen developing countries.

Although criticisms of gross domestic product (GDP) and other aggregate economic indicators were a driving force in the development of environmental accounts, the SEEA emphasizes the accounts themselves rather than calculation of indices like "green GDP." While a green GDP sounds like a good idea, in practice it is hard to design a measure whose meaning is clear. We might like it to be a measure of sustainable income, i.e., the income we can continue to receive without harming any of the assets we use to generate it. However, there is no fundamental agreement on how to define or measure that income.

Instead of measuring sustainable income, green GDP could be a measure of welfare, as hoped by many critics of the conventional accounts. However, a welfare measure would differ from the conventional accounts in fundamental ways that would make environmental accounting data incompatible with the SNA and limit the ability to integrate the two data sets for analysis of links between economic change and environmental quality. The SEEA has been designed largely by national income accountants, who are cautious about creating a system that significantly discards the internal structure and logic of the SNA. Moreover, any measure of welfare is inherently subjective, since individual preferences differ. Both the SNA and the SEEA attempt to measure values that can be defined objectively and that do not vary from person to person. The designers of the SEEA had no interest in creating a system that differed as thoroughly from the SNA as would a measure of welfare.

These priorities mean that the SEEA does not track some of the key issues that might be included in a green GDP measure. While the accounts do track the harm caused by pollution or resource overuse when it passes through the economy – medical expenditures, clean-up costs, forest depletion, and the like – it does not deduct most of them from GDP or other aggregate measures. Moreover, the SEEA does not track harms that are not picked up in the economy – biodiversity loss, harm to other species if it does not have identifiable consequences for humans in the present, and so on. It is hard to put a monetary value on such environmental harm in an objective way, and the SEEA does not try.

Thus the environmental accounts themselves will not provide a measure of sustainability. Nevertheless, the data within the accounts are key components of many of the other indices discussed in this paper, and they are essential for analyzing links between the economy and the environment for policy purposes. The development of a comprehensive set of environmental accounts is therefore an invaluable first step in the measurement and analysis of sustainability.

In the United States, as in most countries, environmental accounts fall under the purview of the organization responsible for constructing the national income accounts. In the US, this is the Bureau of Economic Analysis (BEA), in the Department of Commerce. BEA is not currently building environmental accounts, but EPA's role probably should not extend to developing them in BEA's place. Rather, it should involve collection of the primary data needed to construct the accounts. The development and maintenance of reliable, objective databases on pollutant emissions, environmental protection expenditures, resource use, ambient environmental quality, and other environmental issues, is an appropriate role for a national environmental agency. Like the Bureau of the Census, EPA is well placed to be a provider of basic uniform data, which can then be used by anyone interested in analyzing sustainability issues or constructing indices.

Genuine Saving

Genuine saving is the one exception to the observation that the SEEA does not focus on aggregate indices. Genuine saving is a measure of sustainability rooted in economic principles and based on the national income accounts and the resource use data in the SEEA.[6] Although this index was developed and largely implemented by the World Bank rather than by the accountants designing the SEEA, it has been integrated into the SEEA and can be calculated based on SEEA data.

In the SNA, national saving is a measure of change in the value of manufactured assets. Since, as mentioned above, income is the return on assets, if assets do not decline in value, then as long as the rate of return also does not decline, income will be sustainable. A positive saving rate therefore means that income should be sustainable.

Genuine saving modifies national saving to incorporate change in natural assets, estimates of some harm due to pollution, and change in the value of human capital (the skills of educated people). Changes in all three types of capital—manufactured, natural, and human—are valued in monetary terms and added together to estimate a more comprehensive saving figure for the nation than is calculated in the SNA.

The resulting measure captures key elements of sustainability as that concept is usually understood by economists. By summing the changes in value of different types of capital and seeing whether the outcome is positive or negative, genuine saving implicitly assumes that different kinds of capital are fully exchangeable, making it a measure of weak sustainability. The word "weak" here means that different income sources can be traded off against each other. In contrast, strong sustainability means that each income source must be protected and tradeoffs are not acceptable, or at a minimum natural capital cannot be reduced.

While some environmentalists may feel that no tradeoffs are acceptable between environmental and other assets, and some economists may feel that all tradeoffs are acceptable, most analysts fall somewhere in the middle. Some natural resources, such as plantation forests, can grow back in a relatively modest time frame, so it is acceptable to sell them off in order to

---

[6] Hamilton and Clemens 1999. For the World Bank's most current information on Genuine Saving, (now formally called "adjusted net savings"), and values for most countries worldwide, go to http://www.worldbank.org and use the search option at the upper right to locate "adjusted net savings."

invest in human or manufactured capital if those are more valuable to the society. But other resources, such as biodiversity, cannot be replaced once they are lost. Thus a measure that adds "biodiversity capital" to manufactured capital and tracks total asset value will not measure sustainability.

Minerals, petroleum, and other subsoil assets are not renewable, but decreases in their value are included in genuine saving. The concept of sustainability as applied to non-renewables is understood in several ways. Some people take it to mean that the country possessing them invests in other assets to provide equivalent income once the subsoil assets have been depleted. Others understand it to mean that the country is ensuring the future availability of technologies or assets that will meet the same needs as are now met by subsoil assets; this is clearly a more restrictive concept of sustainability in use of non-renewables. The most restrictive strong sustainability would permit no use of subsoil assets, as they are not renewable in a time frame relevant to contemporary society.

Genuine saving can show us when we are unsustainable, but as with the air quality example discussed above, we can never be sure that we are sustainable. A negative genuine saving rate clearly means that in aggregate we are depleting our assets faster than they are renewed. However a positive saving rate does not guarantee that we are sustainable in the full sense of the term, because the indicator only incorporates some components of weak sustainability. This is a problem with all sustainability indices. It does not invalidate them entirely, but if we use them, we must realize that they are more effective as a flag that something is wrong than as an assurance that everything is okay.

ISEW and GPI

The Index of Social and Economic Welfare (ISEW) and the Genuine Progress Indicator (GPI) are measures of welfare.[7] They take data from the national income accounts as a point of departure, and adjust them to capture a range of social and environmental measures. They both adjust personal consumption figures from the accounts to factor in harm to the environment (pollution and resource depletion), expenditures on education (investment in human capital), and the value of non-marketed household labor (based on the cost of hiring someone to do the work). They make further adjustments to capture what they consider undesirable social problems; income inequality, crime, divorce, and so on.

These measures express social and environmental elements in monetary terms, so they can be added to or subtracted from the economic measures. This leads to a single monetary measure that can be tracked over time to assess how the society is changing. The trend in ISEW or GPI over time is typically compared with the trend in GDP, to make a case that GDP presents society as better off than in fact it is. Neither ISEW nor GPI claims to be a measure of sustainable income, though they do take into consideration all three components of sustainability.

[7] The basic principles of ISEW were set out in Daly and Cobb, 1994. GPI was developed by the California-based nonprofit Redefining Progress; the most current information about it may be found at http://www.rprogress.org/projects. The methodological discussion in this paper is based on Anielski and Rowe, 1998.

These measures raise the same tradeoff concerns as Genuine Saving. They don't allow us explicitly to consider whether it is better, say, to improve the environment (increasing the index) while also increasing crime (decreasing the index), or whether a worse environment with lower crime might be preferable. This is an unavoidable consequence of any aggregate index of sustainability or welfare.

Because ISEW and GPI are measures of welfare, their adjustments for social problems are unavoidably subjective.[8] Both measures weight consumption by poor people more heavily than consumption by rich people. While many people may agree that income distribution is a concern, they may not agree about how much social welfare is reduced by inequity; the choice of the inequity weights is necessarily determined by beliefs rather than objective analytical criteria.

Several other components of these indicators also raise flags about subjectivity. In all welfare measures (including earlier purely economic ones, such as the Measure of Economic Welfare[9]), the treatment of leisure time can be a very large portion of the final index. The choice of how to value leisure – at minimum vs. average wage rates – and how much non-working time should be allocated to leisure can determine whether welfare is observed to rise or drop over time. The designers of the ISEW chose to avoid the issue altogether, and did not impute any value for leisure time. The GPI, on the other hand, takes the 1969 level of leisure as a baseline, and adjusts the index based on differences from that level, using average prevailing wage rates to value leisure. Now it happens that U.S. residents had the highest amount of leisure time on record in 1969, so GPI systematically deducts for the loss of leisure both before and after that year. This choice of baseline pushes the resulting index downwards, whereas use of a different baseline could have led to a much higher welfare measure. The GPI also deducts for other items whose value is clearly in the eye of the beholder. It subtracts all of the legal costs engendered by divorce, an arbitrary amount of about $10,000 per child of divorce, and $0.44 per person-hour of television watched. While conservative Christians might believe that all divorces are bad, and a few intellectuals might consider all television watching to impose social costs, clearly people escaping from abusive marriages or relaxing in front of the tube after a hard day may feel quite differently!

It is because they are measures of welfare that ISEW and GPI appeal to many environmentalists and critics of conventional economic measures. However, it is precisely because they are measures of welfare that it would not be appropriate for EPA to calculate these indices. While EPA does have an important role to play in providing the environmental portion of the data underlying them, government agencies should not use value judgments like those embedded in ISEW and GPI to track national progress.

Material Flow Accounting

Material flow accounts use a framework somewhat similar to the SEEA to track the physical movement of materials in the economy, measuring all flows by weight.[10] In contrast with the SEEA, however, they place significant emphasis on developing macro indicators and less on

[8] Hecht 2002.
[9] Nordhaus and Tobin 1973.
[10] Adriaanse et al. 1997; Matthews et al. 2000

building comprehensive data systems that can be linked to the monetary accounts. National material flow accounts (MFAs) track the weight of several kinds of flows:

- inputs into production,
- outputs produced during production,
- ancillary materials that are filtered out during the production process and become waste (or residuals), and
- materials moved within the environment in order to access natural resources, such as mining overburden or soil excavated during construction.

The last two bulleted items are termed hidden flows in material flow accounting terminology. The tracking of these hidden flows is one of the key structural differences between MFAs and the conventional accounts. They include the hidden flows generated during the production of imports, i.e. the volumes of waste and materials moved in the countries from which imported goods are purchased (sometimes termed the "rucksack"). This is an important item, because it measures the full environmental impact of a consuming society, even if it has exported the impacts by importing finished goods rather than manufacturing them at home. The MFAs sum all four of these flows, including the rucksack, across sectors and materials to calculate the total material requirement (TMR) of the economy. Like GDP, this results in a single number, in this case encapsulating all the flows of physical materials within the economy. Because it includes both domestic and international hidden flows, however, it provides a more comprehensive measure than does an indicator of domestic output.

The significance and policy implications of national indicators such as TMR are not clear. The calculation of TMR involves comparing and summing tons of soil or rocks with tons of highly toxic materials that occur in much smaller quantities. This makes it difficult to understand the meaning of a change in TMR; a decrease might mean that all flows dropped by the same amount or that quarrying and strip mining were replaced with discharges of lead and mercury. Adherence to this so-called "ton ideology" is a major criticism of MFAs in general, and TMR in particular.

Despite this obvious limitation, there has been considerable international interest in MFAs, particularly in Europe. Time series data on such indicators as TMR can be used to track national progress in achieving "Factor 4" or "Factor 10" goals of reducing overall material flows through the economy by a factor of 4 or 10. (Of course the "factor x" measures will suffer from the same limitations as TMR, and may be meaningful only if they pertain to specific rather than aggregate material flows.) Moreover, MFAs do not involve the value judgments inherent in welfare measures, so government agencies are likely to be more willing to construct them than ISEW or GPI.

For these reasons, EPA may be interested in considering work on MFAs. Like other measures, MFAs depend on availability of a wide range of underlying data, whose collection falls within the mandate of EPA and other government agencies such as the U.S. Geological Survey. EPA may want to collaborate with other agencies to collect the data needed to build U.S. MFAs, though compilation of the accounts themselves will probably continue to be the task of non-governmental organizations.

Ecological Footprints and Footprint Accounting

The ecological footprint is a measure of strong sustainability.[11] It focuses on natural resources and the environment and is rooted in ecological considerations, whereas genuine saving is based on economics, and welfare measures integrate all three arenas. Whereas material flow accounts convert economic flows to the weight of material moving through the economy, ecological footprints use land as the common unit of measure, expressing consumption in terms of the area of land or water required to produce, consume, or dispose of the goods or services. The footprint can be calculated at any scale, from the individual to the city to the nation to the world as a whole.

In an effort to bring more rigor to the calculation of ecological footprints worldwide, its designers have expanded it from calculation of aggregate indices to a footprint accounting system that can be constructed for (if not in) all countries in the same way.[12] The accounting system follows that of the SEEA to some extent, but like the MFAs, a country's footprint is based on the environmental impact of the production required to satisfy its consumption, irrespective of where that production occurs.

Like the MFAs, the conversion of all environmental impacts to a single physical unit raises some questions. The system converts all consumption into the surface area in each of six classes—cropland, gardens, forest, pasture, coastal waters, and urban—required to produce a particular product or to manage the wastes resulting from its manufacture or consumption. This includes not only final consumption, but also intermediate inputs such as energy, for which they estimate the forested land area that would be required to sequester all of the carbon emissions resulting from production of that energy. It includes both land and water areas; thus consumption of fish is translated into water areas. The different land and water requirements of each type of consumption are summed to arrive at the total appropriated area of the region, or its ecological footprint. An area's footprint may be divided by its population to measure per capita footprint.

To use the footprint as a measure of sustainability, it is compared with the land area of the region concerned. Available land is not simply the total spatial area; it is a weighted sum of the six surface area classes based on the average productivity of each type of land worldwide. If the footprint is greater than the amount of available land, then the region is depending on the flows from land of other regions (or countries); if it is lower, then the region is supplying flows from land to other parts of the world. Per capita ecological footprints have been calculated for all countries with populations greater than one million, and the results compared with global per capita available land.[13]

The ecological footprint provides a simple flag with which to compare the consumption patterns of very different countries. How useful it is for analytical purposes or assessing sustainability is debatable, however. To meet a sustainability standard by which each country, region, or other unit of scale must keep its footprint within its boundaries, international trade

---

[11] Wackernagel and Rees, 1996
[12] Wackernagel et al, May 2005
[13] WWF 2004

would be quite limited, and cities would not be allowed to depend on their hinterlands. At the extreme, each individual would have to be totally self-sufficient on a discrete plot of land. This concept of sustainability does not recognize any benefit from trade, even if one region is suited only to agriculture while another excels in fishing or has a highly skilled labor supply. This concept in essence says not that the world as a whole must be strongly sustainable, but that each subunit within it must also be strongly sustainable; this is a very extreme version of strong sustainability.

The footprint accounting structure is interesting, particularly because, like the material flow accounts, it allocates the full impacts of consumption to the country engaging in that consumption. Like the MFAs, however, the aggregation of all impacts into a single unit creates problems in this system which leave the results open to question. As with the MFAs, EPA can play a useful role in collaborating with other organizations to provide the underlying data with which to construct footprint accounts, but they may wish to hold off on more substantial involvement in building the footprints.

Environmental Sustainability Index[14]

The ESI is a complex index that, like the ecological footprint and the material flow accounts, aims to measure the sustainability of human use of the environment. Rather than converting all of the underlying components into money, land, or tons, however each one is placed on a scale of one to 100, and the resulting scores are aggregated to form the index. This makes it possible to compare "apples and oranges" without grappling with the problems of converting them all to a uniform numeraire.

The ESI differs from the other indices described here, in that it has several levels of hierarchy in grouping the component variables rather than using a simple sum. It is based on 76 individual measurements, which are combined to form 21 indicators. The ESI is a simple unweighted average of the 21 indicators, although they are also grouped into five categories that capture different elements of environmental impact.

Hierarchical indices are highly subject to how the underlying variables are grouped, as a very simple numerical example will show. Suppose we have six variables, a through f, rated on a scale of one to ten, as shown in the table below. Now consider three different ways to construct an index. The first method has only one hierarchical step; the six indices are simply averaged, as shown in the column headed "No grouping." This gives a value of 3.83.

[14] Yale 2005

Variable name	Variable value	No grouping	Group assignment 1	Group assignment 2
A	2		X	X
B	4		X	X
C	1		X	Y
D	3		X	Y
E	9		Y	Y
F	4		Y	Y
Value of X			2.5	3
Value of Y			6.5	4.25
Overall Index		3.83	4.5	3.625

In the second and third methods, the index is constructed in two steps. First the separate indicators are grouped together and sub-indices are calculated. Here we have two groups, X and Y. Within each group the indicators are averaged to get the sub-index. Then the sub-indices are averaged to get the overall index.

As the table shows, how we assign indicators to groups will significantly affect the value of the index, and an individual indicator—e in this case, since it is an outlier—has more impact on the overall result if it is in a small group than if it is in a big one. This means that in addition to subjectivity in our choice of underlying indicators, we introduce an additional element of subjectivity with each level in the index hierarchy.

The developers of the ESI are very much aware of these problems, which is why they calculate a simple average of the 21 composite indicators, and do not average the five indicator groups. The way in which the 76 underlying measures are combined to form the 21 indicators may still create problems. To address these concerns, as well as to allow individual countries to tailor the index to better reflect their own environmental concerns, the index's developers are planning to create an interactive version of the calculation system with which individual users can vary the weights and create new indices.

The ESI is being calculated annually Yale's Center for Environmental Law and Policy and Columbia's Center for International Earth Science Information Network (CIESIN), following a well-documented and consistent methodology. For this reason, and because it is a quite simple measure which has received a fair bit of press attention, it is easy for EPA to track U.S. performance according to this index. However, it is neither a measure of overall sustainability, as it focuses only on environment, nor even an attempt to actually account for strong sustainability, as the ecological footprint does. Its utility in the U.S. may be more as a political tool, which environmental groups can use in calls for greater government commitment to environmental protection, than as a policy tool for decision-making within the government. EPA may also wish to use it as a flag to call attention to U.S. environmental issues or compare our performance as protectors of the environment with others around the world. However it will not help EPA to introduce sustainability as a benchmark for evaluating national progress.

Conclusions

While much discussion and effort has gone into sustainability indicators, none of the resulting systems clearly tells us whether our society is sustainable. At best, they can tell us that we are heading in the wrong direction, or that our current activities are not sustainable. More often, they simply draw our attention to the existence of problems, doing little to tell us the origin of those problems and nothing to tell us how to solve them. Measures of welfare embody subjective assumptions about what is good and bad for us as a society; these are clearly open to debate and will certainly elicit considerable disagreement if they are understood. Although they can provide a useful basis for debate about societal values and conflicting interpretations of welfare, they do not offer us an objective way to assess our activities or progress.

These limitations suggest that EPA should not be directly engaged in constructing any of these indicator systems. In the case of the environmental accounts, the Bureau of Economic Analysis has explicit responsibility for building them, while the subjectivity of welfare measures suggests that they should be constructed outside of the federal government. EPA is, however, well suited to developing the primary data on which all of these systems depend. As the primary federal agency responsible for environment, the EPA has the authority to collect primary data about the country, and the institutional structure to maintain data collection institutions that will continue over time. No non-governmental organization has either the mandate or the resources to play this role.

When such data are collected by a respected federal agency and made readily accessible to the public, other organizations can easily step in to construct indices and accounting systems using the information. The results may be of considerable importance both for policy analysis and for advocacy, even though none of the measures will provide a definitive measure of sustainability. EPA itself is likely to make use of measures constructed based on its own data, even though it may not be appropriate for it to construct those measures itself. And the data that EPA can provide to other organizations will be invaluable both within the agency and outside of it, for focused analytical work and for broad assessment of progress towards social goals.

References

Adriaanse, Albert, Stefan Bringezu, Allan Hammond, Yuichi Moriguchi, Eric Rodenburg, Donald Rogich, and Helmut Schütz. 1997. *Resource Flows: The Material Basis of Industrial Economies.* Washington, D.C.: World Resources Institute.

Anielski, Mark and Jonathan Rowe. 1999. *The Genuine Progress Indicator: 1998 Update.* San Francisco: Redefining Progress. Available through http://www.rprogress.org.

Diamond, Jared. 2005. *Collapse: How Societies Choose to Fail or Succeed.* New York: Viking Penguin.

Daly, Herman E. and John B. Cobb, Jr. 1994. *For the Common Good: Redirecting the Economy toward Community, the Environment, and a Sustainable Future.* Boston: Beacon Press.

Hamilton, Kirk, and Michael Clemens. 1999. "Genuine Savings Rates in Developing Countries." *World Bank Economic Review* 13(2): 333–56. Available at http://www.worldbank.org/research/journals/wber/revmay99/pdf/article5.pdf.

Hecht, Joy. 2002. "Green National Income, Measures of Welfare, and Ideological Bias." Paper presented at the biennial meeting of the International Society for Ecological Economics, Sousse, Tunisia, March 2002. Available at http://www.joyhecht.net/professional.html.

Hecht, Joy. 2005. *National Environmental Accounting: Bridging the Gap between Ecology and Economy.* Washington, D.C.: Resources for the Future.

Matthews, Emily, Christof Amann, Stefan Bringezu, Marina Fischer-Kowalski, Walter Hüttler, René Kleijn, Yuichi Moriguchi, Christian Ottke, Eric Rodenburg, Don Rogich, Henz Schandl, Helmut Schütz, Ester van der Voet, and Helga Weisz. 2000. *The Weight of Nations: Material Outflows from Industrial Economies.* Washington, D.C.: World Resources Institute.

Nordhaus, William D., and James Tobin. 1973. "Is Growth Obsolete?" In Milton Moss, ed., *The Measurement of Economic and Social Performance,* Studies in Income and Wealth, Volume 38, by the Conference on Research in Income and Wealth. New York: National Bureau of Economic Research.

United Nations Division for Sustainable Development. "Indicators of Sustainable Development." Available at http://www.un.org/esa/sustdev/natlinfo/indicators/isd.htm.

United Nations, European Commission, International Monetary Fund, Organization for Economic Cooperation and Development, and World Bank. 2003. "Handbook of National Accounting, Integrated Environmental and Economic Accounting 2003*.*" Final draft circulated for information before official editing; to be issued in *Studies in Methods*, Series F, no. 1, Rev. 1 (ST/ESA/STAT/SER.F/1/Rev.1). Available at http://unstats.un.org/unsd/envAccounting/seea.htm.

Wackernagel, Mathis, and William Rees. 1996. *Our Ecological Footprint: Reducing Human Impact on the Earth*. Gabriola Island, British Columbia, and Philadelphia: New Society Publishers.

Wackernagel, Mathis, Chad Monfreda, Dan Moran, Paul Wermer, Steve Goldfinger, Diana Deumling, and Michael Murray. 2005. "National Footprint and Biocapacity Accounts 2005: The Underlying Calculation Method." Available at http://www.rrcap.unep.org/uneptg05/outline/synthesis/Footprint_Method_Paper%5B1%5D.pdf.

WWF. 2004. *Living Planet Report 2004*. Available at http://assets.panda.org/downloads/lpr2004.pdf.

Yale Center for Environmental Law and Policy and Center for International Earth Science Information Network, Columbia University. 2005. *2005 Environmental Sustainability Index: Benchmarking National Environmental Stewardship.* New Haven: Yale University. Available at http://www.yale.edu/esi/.