

## **PROGRESS IN THE MEASUREMENT OF SUSTAINABLE DEVELOPMENT**

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### **Summary**

The call for countries to pursue policies aimed at achieving ‘sustainable development’ was established both in the Brundtland Report in 1987, the Earth Summit in 1992 and, more recently, at the World Summit in 2002. Sustainable development has been now adopted as an over-arching goal of economic and social development by United Nations agencies and by many individual nations, local governments and even corporations and further has generated a huge literature. It is clear that formidable challenges confront policy-makers who have publicly stated their commitment to the goal of sustainable development. While not a substitute for policy, an important step toward making sense of these commitments is through efforts to measure sustainability.

In this chapter, we survey a diverse range of efforts to measure sustainable development and environmental sustainability. This leads to a variety of conclusions, most notably, that a great deal of progress has been made in constructing practical indicators over the past 15 years or so.

Within the field of green national accounting, many of the pieces of the puzzle required to understand – in theory – adjustments to accounting aggregates and the implications (and caveats) of not enough saving to sustain (total or per capita) welfare are now known. Of course, the provision of sustainability indicators is an essentially empirical objective and so it is on this practical basis that progress must ultimately be judged. Interestingly, in practical terms, a wide range of data on national-level resource depletion and environmental degradation now exist. This chapter has provided numerous practical illustrations. Outside of the province of green national accounting, an additional array of actual indicators has been proposed. Again, we provide a number of illustrations including those based on notions of ‘ecological footprints’ and environmental thresholds.

What is a suitable response to this array of candidate sustainability indicators given that these measures can give apparently conflicting signals about development paths? A reasonable expectation is that, over time, many of these indicators will wither on the vine. It is to be hoped that those that survive this process are the most useful. However, this outcome cannot simply be assumed. Hence, candidate indicators need to be properly scrutinized by researchers rather than accepted at face value.

The end goal of such scrutiny should not be reliance on a single indicator. In general, it is not credible to think that either any single measure can describe all relevant aspects of the development path. A better picture of whether countries are developing sustainably will require a judicious mix of indicators. Establishing what should be included in this portfolio is a major challenge for future research.

## **1. Introduction**

The call for countries to pursue policies aimed at achieving ‘sustainable development’ was established both in the Brundtland Report in 1987, the Earth Summit in 1992 and, more recently, at the World Summit in 2002. Sustainable development has been now adopted as an over-arching goal of economic and social development by United Nations agencies and by many individual nations, local governments and even corporations and further has generated a huge literature. It is clear that formidable challenges confront policy-makers who have publicly stated their commitment to the goal of sustainable development. While not a substitute for policy, an important step toward making sense of these commitments is through efforts to measure sustainability. That is, alerting decision-makers to the underlying ‘true’ trends in the economy is a prerequisite to informing decision-making that is not systematically biased towards the well-being of the current generation.

In this chapter, we survey a diverse range of efforts to measure sustainable development and environmental sustainability. One means of making sense of this diversity is with reference to the distinction between weak and strong sustainability (hereafter WS and SS respectively). Although this characterization is somewhat crude, it is capable of identifying important differences between ‘economic’ and ‘ecological’ approaches to measuring sustainability respectively. The fundamental distinction between WS and SS is that the latter: (a) denies to a greater or lesser extent, substitutability between natural assets and other assets (e.g. human and produced capital) and; (b) stresses ‘thresholds’, ‘discontinuity’ and ‘non-smoothness’ in ecological systems and hence in the economic damages to which ecological impairment gives rise (referred to as “non-convexities” in the conventional environmental economics literature). In effect, SS takes as its starting point ecological imperatives and this dictates the subsequent form of economic analysis. By contrast, WS begins with standard assumptions in economics and this in turn shapes the form in which ecological and environmental concerns are evaluated.

In terms of indicators of sustainability, different indicators are relevant to the two paradigms, as illustrated in Figure 1. The WS paradigm emphasizes the substitutability of produced and natural assets and hence focuses on aggregate measures such as: (a) green national income or green Net National Product (*NNP*) and, increasingly (b) genuine savings (the net savings rate in an extended or green national accounting framework) or

the net change in wealth per capita. In the main, these indicators are intended to measure sustainability at the national level, but it is as well to note in passing that the WS approach also affects microeconomic indicators; in particular, it affects cost-benefit measures.

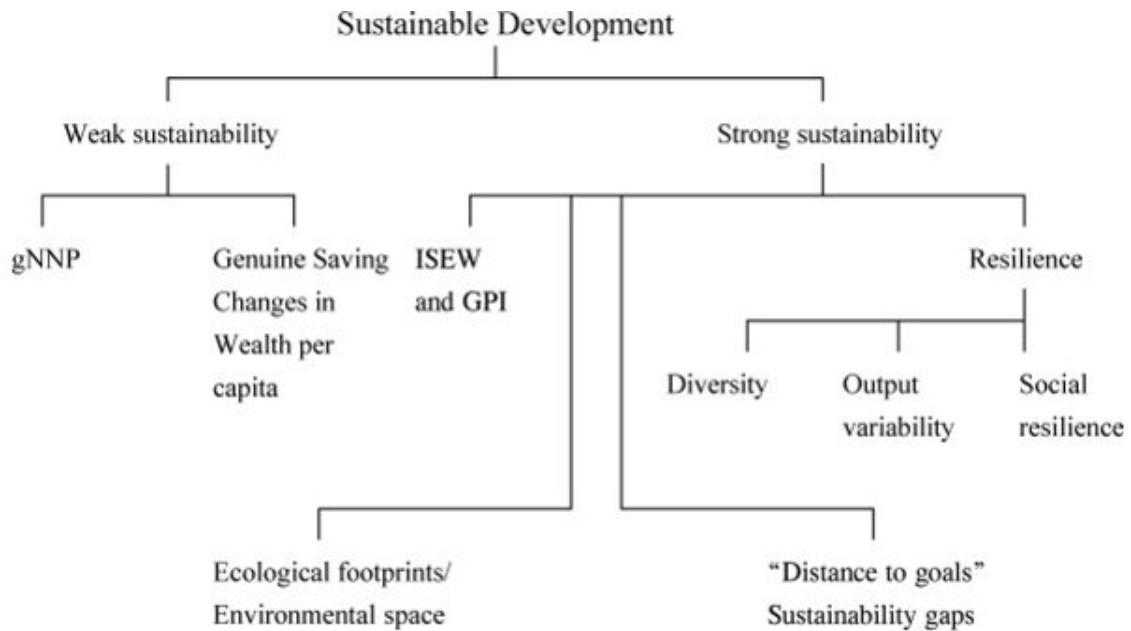


Figure 1: A Typology of Sustainability Indicators

Approaches that seek to construct SS indicators are far more varied than for WS. Some of these indicators are disaggregated approaches presenting a range of indicators reflecting different aspects of environmental change. Others present aggregate measures purporting to provide a synoptic picture of whether countries or regions are strongly sustainable. Indicators in these categories include the following. (a) ‘Distance to goal’ or sustainability gap approaches, in which the distance between the current status of environmental indicators and sustainability ‘targets’ is calculated; (b) Measures of carrying capacity: e.g. incorporating supply/ demand ratios for resources; (c) The ecological footprint or environmental space of a nation, region or city, with implications for an area’s fair share of global resources (particularly with respect to the latter); (d) Measures of resilience, most of which have yet to be developed. One suggestion involves indicators of biological diversity, since resilience is assumed to be a function of diversity; (e) The Index of Sustainable Economic Welfare (ISEW) and Genuine Progress Indicator (GPI).

The remainder of this chapter is organized as follows. In Section 2 we review the basic models that have been used to examine sustainable development in theory. This discussion places a particular emphasis on the theory of green national accounting, which has most to say about WS approaches; however, we also explore links with SS approaches. Section 3 provides an overview of practical indicators of WS focusing on the role of saving rules, measurement issues and caveats to savings rules. In Section 4, we move on to consider practical indicators of SS and in doing so illustrate a relatively wide variety of proposals. Finally, in Section 5 we draw this discussion together by reflecting on what progress has been made in measuring sustainable development from both the WS

and SS perspectives and identify a number of challenges for future research.

## 2. Sustainability Models

It is over a decade since the early shaping of the sustainability problem in the Brundtland Report. In that time, substantial progress has been made in clarifying the many controversial issues that have emerged. The concept of sustainable development has itself been defined in a number of ways. The Brundtland Report defined it as “*development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs*” (WCED, 1987, p43). Others have interpreted the meaning of sustainable development somewhat differently. For example, economists have tended to reinterpret this as a requirement to follow a development path where human welfare or well-being per capita does not decline. Arguably, this focus has led to a consistent and interesting ‘story’ about sustainable development: what it is, what the conditions are for achieving it, what might have to be sacrificed to obtain it, and how it can be measured. Of course, there are other ways of addressing the sustainable development debate. For example, for some commentators, sustainable development implies a rather different focus on procedural concerns such as a requirement for greater public participation in decision-making. In addition, other contributors have placed a distinct emphasis on “social sustainability”. This can be traced to the Brundtland Commission emphasis on the role of the essential *needs* of the world’s poor, which extends the notion of sustainable development. This suggests that distributional issues within the current generation are also relevant to the policy-maker’s problem. If so, then this requires that policy-makers follow a more specific requirement to prohibit not only current development which was at the expense of the future, but also increases in wellbeing for the better off in society which came at the expense of those who were worse off.

An important question is how a sustainability goal of non-declining welfare per capita is to be achieved. Common to most theories of sustainable development is an emphasis on aspects of the environment (e.g. commercial natural resources, clean air and water, biodiversity etc.) as natural assets. Furthermore, there is near common agreement that development policy in the past has not paid sufficient attention to this particular component of wealth. Where theories diverge is in offering very different perspectives on the ability to substitute produced and human assets for natural assets. Not surprisingly, this has important implications for the way in which we should measure sustainability.

For *weak sustainability* (WS) any one form of capital can be run down provided ‘proceeds’ are reinvested in other forms of capital. Put another way, it is the ‘overall’ portfolio of wealth that is bequeathed to the future that matters. This, in turn, is based on a rule of thumb known as the Hartwick rule (or sometimes the Hartwick-Solow rule) (Hartwick, 1977). This states that the resource rents (depletion of commercial resources each valued according to its unit rent) should be reinvested. However, this reasoning also extends to the value of changes in environmental liabilities arising, for example, as a result of pollution. More generally, the basic requirement for WS is that the change in the (real) value of total wealth should not be negative in the aggregate.

A good illustration of the theory of indicators based on WS is provided by the literature on green national accounts. This work arises from a concern that economic indicators,

such as Gross National Product (GNP), do not reflect the depletion and degradation of the environment and so may lead to incorrect development decisions, in much the same way that cost-benefit analyses that do not include the values people place on the environment may yield poor investment decisions.

Some basic results from this theoretical work are discussed below. This literature builds on important contributions by Weitzman (1976), Hartwick (1990) and Mäler (1991). This framework is “extended Hicksian” as its focus is on accounting for the value of changes in total wealth in national income. National income is typically defined along the optimal path of a growth model for a simple economy with stocks of goods (including natural assets used in production) and bads (including environmental liabilities that negatively affect utility). An example of the application of this framework is the following expression for the basic (net) national income aggregate:

$$NNP = C + \sum p_i \dot{X}_i = C + G \quad (1)$$

NNP is equivalent to consumption ( $C$ ) plus the sum of net changes in  $i$  assets ( $\dot{X}_i$ ) each valued at its shadow price ( $p_i$ ). This assumes a simple economy in which a single composite good is produced by production function  $F(K, L, X)$ , and that this good can either be consumed or invested. Society wishes to maximize the present value of utility for an aggregate utility function  $U(C, X)$ , where  $C$  represents consumption and  $X$  stocks of goods and bads.  $K$  and  $L$  are (manufactured) capital and labor respectively. Alternatively, this can be written as consumption plus genuine saving ( $G$ ). An interpretation of NNP is that it measures extended Hicksian income: that is, the maximum amount of produced output that could be consumed at a point in time while leaving wealth (instantaneously) constant. Given an interpretation of sustainability that the change in the (real) value of total wealth should not be negative in the aggregate, this definition of Hicksian income suggests that our focus should be on genuine saving or  $G$ . The reason for this is that  $G$  tells us about (net) change in wealth ( $W$ ) in that it can be shown that:

$$\dot{W} = 0 \text{ if } G = 0 \quad (2)$$

The key finding in this literature is that a point measure of  $G_t < 0$  means that path is unsustainable. That is, welfare must decline over some interval in the future. However, it is important to note that a point measure,  $G_t > 0$ , does not necessarily mean that path is sustainable. In other words,  $G$  is a one-sided indicator of sustainability. The proposition that negative genuine saving is unsustainable holds for a variety of circumstances, outside the usual “optimal growth” framework of standard models: these include non-optimal development paths, situations where the discount rate varies over time, and “non-autonomous” cases in which time plays an independent role, such as where exogenous technological change influences the development of the economy.

Another issue is how (weak) sustainability should be measured when population is growing. That is,  $G$  measures only the change in total wealth whereas, in much of the

developing world, the reality is that population is growing at relatively rapid rates. In such circumstances, the net change in total wealth per capita is a better measure of sustainability (than the genuine savings rate). This can be written as follows:

$$\frac{d}{dt} \left( \frac{W}{N} \right) = \frac{\dot{W}}{N} - \frac{gW}{N} \quad (3)$$

where  $W$  is total wealth,  $N$  is total population and  $g$  is the population growth rate. Hence, the net change in total wealth per capita,  $d(W/N)/dt$ , is equal to change in total wealth (i.e.  $\dot{W}$  or  $G$ ) divided by total population ( $N$ ) minus the product of total wealth per capita ( $W/N$ ) and the population growth rate ( $g$ ). This latter component of the (right-hand side of the) above expression can be thought of as a ‘Malthusian’ term, which represents the sharing of total wealth with the extra people implied by a country’s growth in population. Clearly, for a population growth rate that is strongly positive then  $d(W/N)/dt$  could provide a very different signal to policy-makers about sustainability prospects than the ‘traditional’ genuine savings rate.

In the above, indicators of sustainable development have been discussed with reference to scrutinizing either changes in total wealth (i.e. genuine saving) or changes in wealth per capita. Measuring changes in natural assets – such as depletion of resources stocks or accumulation of environmental liabilities – is clearly a crucial element of this. However, in this WS world, there is no specific focus on the environment in that – within these frameworks – an assumption is made that there are no particular things that we owe to future generations. Of course, it is worth noting that WS does not eschew conservation altogether. To the extent that society is, for example, over-consuming a natural asset, i.e. in excess of efficient levels of use, proponents of WS would typically advocate more conservation than currently prevailed. Nevertheless, the defining feature of WS is the proposition that it is by passing on some generalized productive potential, broadly construed, that future welfare will be sustained.

Advocates of SS as a guiding principle argue that it is the physical protection of absolute levels of ecological goods that is a prerequisite for sustainability. Reasons for this include the complexity of ecosystems and the view that the diminished capacity of the environment to provide functions, such as waste absorption and ecological system maintenance, cannot be replaced or substituted. Furthermore, it is argued that natural assets are characterized by important thresholds, that if exceeded lead to large-scale and irreversible ecological losses with possibly dramatic implications for negative impacts on human well-being. There are several variants on this proposition. For example, very few supporters of SS (explicitly) argue that all natural assets must be conserved. More usually it is argued that there are *critical* natural assets, crucial for human welfare that have no substitutes and therefore cannot be traded off for other forms of wealth.

It is useful to ask how the two ways of looking at the question of sustainability (i.e. WS and SS) are linked. That is, can the two approaches complement one another or does each represent an exclusive perspective on the world in which we live? Within the green national accounting framework that has so far proved the bulwark of WS approaches, one way of capturing the SS notion of a critical amount of a resource or natural asset is by

assuming that,

$$p_i \rightarrow \infty \text{ as } X_i \rightarrow \bar{X}_i^+, \quad (4)$$

where,  $\bar{X}_i^+$  is the critical amount of the natural asset – i.e., as the resource declines to the critical amount, arbitrarily large losses in welfare are associated with depletion of a marginal unit. This could correspond to a physical process, such as rapid deterioration in forest quality and diversity once a critical threshold has been breached. In principle, the resulting adjustment to *NNP* and *G* would show up as a correspondingly large loss in value of the critical natural asset (i.e. as its stock level reaches the critical amount). If preferences for critical resources are taken into account, then the optimal or most socially desirable policy is to be strongly sustainable (i.e. set limits on resource depletion so as to avoid the prospect of rapidly increasing losses in welfare). Yet, while this approach can handle strong sustainability in principle, in practice it requires good measures of willingness to pay for a critical resource and sufficient scientific and economic information (concerning the relative importance of the loss of the resource) for preferences to reflect the appropriate trade-offs that would underpin this willingness to pay estimate.

If policy-makers focused only on the essential idea that a given physical amount of a resource must be preserved intact in order that it may continue to provide critical services, a two-tier approach to sustainability is suggested. One approach is that of a safe minimum standard (SMS) in such terms whereby policy-makers follow standard cost-benefit rules unless there is a compelling reason not to; e.g. to conserve a critical natural asset. (However, this conservation rule can itself be overridden if its costs are “intolerable”.) Take an example of a tropical rainforest, where preserving some quantity of the forest is considered to be critical for the long-term well-being of humanity. The effect of this preservation is to reduce the amount of forest that can be considered to be an economic resource (i.e. it reduces the quantity of harvest that can be carried out from the non-conserved stock). The key indicators for a country with tropical forest operating under this regime will be twofold: are stocks of this critical natural asset declining? and are genuine savings rates (i.e. savings net of the change in the non-conserved resource stock) negative? A positive answer to either of these questions would be an indication of unsustainability.

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### **Biographical Sketches**

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