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Meeting Conceptual Challenges

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The concept of sustainability and its measurement with indicators may seem intuitively simple, but it is difficult to implement in practice. Over the past two decades some problems have been resolved and much progress made on others, but major challenges remain. This chapter summarizes the present conceptual challenges, illustrated by selected indicator approaches. The challenges are grouped in two clusters: measuring sustainability and sustainable development, and developing indicators through processes that ensure their universal applicability. These various conceptual challenges suggest future research agendas and approaches to indicator use.

Measuring Sustainability and Sustainable Development

The usefulness of any indicator intended to measure how sustainable (or unsustainable) the world is, or the progress society is making toward sustainable development, naturally depends on how these terms are defined. Although this was discussed briefly in chapter 1, it still provides the major conceptual challenges for indicator development. First, it is necessary to go beyond a sectoral approach to a system approach. Does sustainable development fit a linear model with three or four pillars? Are there alternative, system-based approaches to understanding and measuring sustainability? Second, the entity to be measured must be defined in temporal and spatial scales and related to some model for sustainable development. What does sustainability mean for a village, a country, or the planet? Over what time span should the world, its ecosystems, and humanity sustain themselves and in what form?

From Pillars to Linkages to Systems

It has become common to consider sustainable development within a certain conceptual framework, and this also influences indicator development. In Agenda 21 and at the UN World Summit on Sustainable Development (WSSD), the international community refers to economic, social, and environmental dimensions or pillars of sustainable development (UNCED 1993; United Nations 2002). In some contexts a fourth institutional pillar is added, as in the framework for indicators adopted by the Commission on Sustainable Development (CSD).[1] Alternatively, institutions are seen as providing the underlying enabling mechanism for effecting action and change in any of the pillars. Most of the present approaches to indicator development compile indicators for these pillars. There has been much progress in developing indicators within each pillar, and many such indicators are being implemented.[2]

Others prefer to see sustainable development as the interaction of the environmental and human systems in a two-part coupled framework (e.g., Prescott-Allen 2001). Many national and international bodies arrange their indicators in a "pressure–state–response framework" (sometimes expanded with "driving forces" and "impacts": DPSIR). Although this framework implies causal relationships between indicators, research has only recently begun to develop the data and models necessary to interrelate indicators in such a framework.[3] Significant conceptual challenges remain even when we consider single indicators (and further challenges for aggregated indices). For example, there is limited understanding of how the complex properties of the social dimension reinforce or obstruct sustainable social development. Concepts such as social capital are emerging as aspects relevant to social cohesion but have not yet been captured in indicators, and more work is needed to evaluate their usefulness. There are similar challenges in the institutional pillar, as indicated by the very few institutional indicators included in the CSD list (UN Division for Sustainable Development 2001). Economic indicators are well established but do not include measures of long-term sustainability in the economic system.

All these approaches are limited in that they address isolated elements of sustainability. Sustainability and sustainable development are characteristics of integrated systems with multiple linkages, feedback loops, and interdependencies. Although political approaches to sustainable development often are narrowly sectoral, with little focus on integration in practice, decision makers are increasingly asking for indicators to help build mutually reinforcing links between pillars. The challenge of defining and quantifying links between the pillars has not been resolved, but some progress has been made in the last decade, and examples are available (Table 2.1).

The fundamental conceptual challenge is to go beyond a mere collection of parts and apply a more system science–oriented approach to consider the sustainability of whole systems composed of interacting subsystems with emergent system properties (Chapter 10, this volume). It is the underlying properties that determine the dynamics and behavior of these systems and ultimately how sustainable the systems are over long periods of time. Examples of such system properties are resilience, carrying capacity, energy and material flows, and intergenerational knowledge transfer.

Table 2.1. Interlinkage indicators in the four-pillar sustainable development framework.

Linkage	Indicators
Environmental–economic	Resource productivity (gross domestic product/total material input) (Eurostat 2001; OECD 2001). Transport intensity (Böge 1994; SDC 2004).
Socioeconomic	Labor productivity (production per capita; see any national labor statistic). Income distribution per decentile (see any national social statistic).
Socioenvironmental	Environmental health problems (no clear definition so far; work under way by the World Health Organization, European Environment Agency, and others). Access to common goods (to be specified regionally, available in Scandinavia under traditional law).
Economic–institutional	Corruption rate (Transparency International Index I). Share of taxes on labor, capital, and the environment in total tax revenues (not often calculated, but the basic data often are available from national statistical offices).
Socioinstitutional	Co-decision rights of workers (e.g., according to the European Works Council directive; in Europe, data are available from Eurostat labor market statistics, from the EU Commission, the trade unions, and others). Reliability of the health care and social security system (reliability is a subjective term and so far undefined).
Environmental–institutional	Nongovernment organizations' right to file suit (data for this are collected under the Aarhus Convention demanding such access). Freedom of information (in Europe, North America, and Central Asia regulated by an UN Economic Commission for Europe directive adopted in 1998 as a minimum standard).

Source: Spangenberg and Hinterberger (2002).

Only rudimentary efforts have been made to look at system properties and processes of integrated human, social, and economic systems. Many of the best-known indicators and indicator sets fail to include any such overall system properties, and they focus on more limited aspects of sustainable development (Chapter 11, this volume). For example, the CSD set assembles a large number of indicators but does not permit any judgment on the sustainable behavior of the system as a whole (Chapter 10, this volume). A more qualitative approach is to develop scenarios for alternative futures that span all the dimensions (e.g., Millennium Ecosystem Assessment 2005; UNEP 2002). These are sometimes generated by models (e.g., Meadows et al. 1992), in which case quantitative data and indicators can be both fed into and generated from the models. Modeling approaches provide tools to explore system behavior, identifying which factors are important and how sensitive the system is to variations in different indicators. Linking indicators with models will eventually provide more integrated perspectives on measuring progress toward sustainability.

Expanding the Temporal and Spatial Scales

Sustainability is a concept inherently related to time and space. What spatial unit should be sustained for how long? The approach to such questions differs between policymakers and scientists and depends on their focus on specific sectors or pillars of sustainable development.

With respect to the temporal dimension, each pillar is characterized predominantly by different time dynamics in, for example, lag times between cause and effect or the time horizon for policymaking. Sustainability in general is a long-term concept. Environmental issues have the longest range of temporal horizons, from floods or toxic emissions, to gradual changes over decades in the atmosphere, oceans, and climate caused by human action, to slow natural processes over millennia such as evolution and species formation, to the "death" of the sun. At the other extreme, economic issues involve very short-term decisions and impacts ranging from daily exchange figures to a few decades for infrastructure investments, with the future being discounted so that anything beyond that becomes irrelevant. Social issues generally fall between these two extremes, taking the length of a human life as an appropriate time frame, although negative effects on the social life of a generation, such as mass unemployment or poverty, can have impacts on the self-esteem and behavior of future generations (Arendt 1981).

The challenge for sustainability indicators is to anticipate such time lags and the trade-offs between the short and long terms. In developing highly aggregated indices, it may be worthwhile to consider weighting the time scales of the different pillars, giving higher weights to long-term or irreversible effects, for example, in order to improve their comparability.

For the spatial dimension, there are similar differences and specificities for each pillar. The relevant boundaries of a function or process may or may not correspond to the political boundaries of nation-states. Economic transactions increasingly span the globe, communities and cultures transcend national borders, and ecosystem boundaries range from puddles of water to biomes.[4] Yet indicators for all three pillars are generally remapped onto political (usually national) boundaries. Indicators for local communities are also common, but there are almost no indicators measuring the sustainability of the planetary biogeochemical life support system or of humanity as a species at the global scale.[5]

A consequence of this spatial fragmentation is that trends and drivers are easily hidden when analyzed at one particular scale. A nation or local community can appear sustainable if it does not consider its impact on the sustainability of close and distant neighbors. Similarly, indicators portraying good average values, for example in income, can hide significant inequities between subregions and societal groups at smaller spatial scales.

The challenge is to develop indicators that capture issues of sustainability at different spatial scales, in a nested hierarchical structure that links the scales with some scientific consistency while reflecting what can be managed at each level. The same indicator may have different meanings for sustainability in different contexts or when applied at different scales, so each use is context specific. Some approaches such as material flow analysis and energy flow analysis with proper data and modifications can be scaled up and down.[6]

Strong versus Weak Sustainability

One approach that discusses and even measures degrees of sustainability is the notion of weak and strong sustainability (Turner 1993). It was derived from the economic concept of capital, defined as a stock of resources with the capacity to give rise to flows of goods and services.[7] Ecological economists have expanded the concept to disaggregate the capital stock into four types (Ekins 1992) and linked them to the four dimensions of sustainability, including the institutional dimension (Spangenberg 2001):

- Manufactured capital: result of past material production (excess of output over immediate consumption)
- Human capital: people, skills, and knowledge
- Social and organizational capital: social networks and organization
- Natural capital: all features of nature providing resources for production and consumption, absorbing wastes, and furnishing amenities such as natural beauty

The issue is the substitutability of the different forms of capital in achieving sustainability of the whole system. Weak sustainability requires that the total capital stock (aggregated over the four types) does not decline. This presumes that all types of capital are substitutable in their capacity to generate human welfare and maintain system functioning. Strong sustainability requires that the stock of natural capital be maintained above critical levels. This assumes that substitutability regarding welfare generation is limited, or it applies sustainability criteria broader than welfare maximization. It entails the physical protection of certain absolute levels of natural capital, which cannot be substituted without provoking major and unpredictable system perturbations. The challenge for indicator development is not to give the final answer to the question of whether weak sustainability is sufficient but rather to map out where on the scale of weak to strong sustainability current drivers and policies are heading regarding the fraction of human well-being that can be expressed in monetary values. The subjectivity of assigning such values to all dimensions, describing them as different types of capital, is controversial, but it does enable the integration of social and natural aspects with the economic indicators that usually dominate the political agenda.[8] However, other elements of sustainability must be measured in other units, providing complementary but indispensable information.

A number of indicators and frameworks have been developed in the context of this discussion. For example, the "green" net national product has been proposed as a measure of the return on the aggregate of all capital types, but it requires reliable market values of all elements of the natural capital stock. On the other hand, the Critical Natural Capital (CRITINC) Framework recently introduced the concept of critical natural capital as those stocks of capital that cannot be substituted by other stocks of environmental or other capital to perform the same functions (Ekins et al. 2003). However, these indicators are very scale dependent, and evaluations of weak and strong sustainability must be considered at different temporal and spatial scales.

Finding the Planetary Limits

Carrying capacity is a familiar concept in ecology and refers to the population sizes of species that a particular ecosystem can sustain over time. In the context of measuring sustainability, it has been extended to the human species and refers to the numbers of people that can be maintained in the coupled human–environment system within planetary limits.

The difficulty in considering a species such as humans, who are able to raise the productivity of their own environment, is that carrying capacity, like sustainability itself, is a subjective and normative concept that depends on political choices of the spatial and temporal horizons considered and the preferred types of environmental, social, and economic systems. In environmental systems, for example, the carrying capacity depends on the limits set for the subsystem being analyzed and the acceptable level of degradation that can be tolerated in the system.

The only objective dimension to carrying capacity concerns the ultimate limits of maintaining conditions for life on the planet. Except for energy, the biosphere is essentially a closed system, and this imposes ultimate biophysical limits on growth in any material parameter at the planetary level. As resource limits are reached, further growth can come only from increases in efficiency.[9] Human technological development allows us to reach those limits and has even given us the military capacity to exterminate ourselves, and our ignorance of biosphere systems can give us the illusion that there is no need to

be precautionary. The difficulty is that the inertia in planetary systems produces long time lags between our impacts and the resulting consequences (Meadows et al. 1992). This again justifies efforts to develop global-scale indicators (Chapter 10, this volume).

Although science should determine the ultimate biophysical carrying capacity of the planet as the outer limit for long-term sustainability, only subjective choices can decide the second crucial dimension of human carrying capacity: the acceptable standard of living for the people within the system. A finite set of resources can provide abundance for a few or bare subsistence for many. This gives sustainable development an important dimension of redistributive justice both in space (relative wealth and poverty) and in time (intergenerational equity).

The environmental space concept and Ecological Footprint index effectively communicate the concept of planetary carrying capacity in one dimension, the spatial one, by calculating how much space is needed to meet the needs of an individual, community, or nation, as related to the space available (EEA 1997).

Exploring Vulnerability and Resilience

Vulnerability and *resilience* are two terms that are increasingly used in scientific analysis of sustainable development from a system perspective. Whereas many concepts focus on the outer limits to sustainability, these terms apply to the inner limits to sustainability in a particular system. Although there is still a need to clarify and consolidate how these concepts are defined and applied, resilience is the capacity of the coupled human–environment system to cope with internal or external disturbance and its ability to adjust and adapt (Gutiérrez-Espeleta 1999). This applies to the social, economic, and environmental subsystems. Vulnerability is a characteristic of the lower end of the resilience spectrum. A system with high resilience has low vulnerability and vice versa. Systems need resilience not only to normal variations but also to extreme events, whether floods, droughts, or sudden drops in the stock market.

The increasing attention to these concepts has led to policy requests for indicators of resilience and vulnerability, such as in the UN Programme of Action for Small Island Developing States (United Nations 1994). Examples of responses are various economic vulnerability indices (Briguglio 1995) and the Environmental Vulnerability Index (EVI) (Pratt et al. 2004). The latter focuses on the environmental resources and ecosystems on which human society depends and profiles how vulnerable they are to further disturbance.

Indicating Irreversibility

When a system is not resilient enough to absorb disturbance and is degraded, the changes often are irreversible. It is the irreversible changes that are critical to sustainability. Irreversibility defines an absolute limit beyond which reestablishing the status quo is not possible. The concept of irreversibility is inherent in any analysis of coevolving systems. However, so far it is used primarily for environmental systems, describing events such as species extinctions or permanent loss of vital ecosystem functions, and is an essential part of identifying reference values. The approach is very different in the social and economic sphere. Social systems are characterized by permanent change, and irreversible changes would be those that have impacts lasting more than two generations, for the better or for the worse. In economics, whereas more recently emerged subdisciplines such as evolutionary and ecological economics analyze irreversibility and the resulting path dependency of system development as a characteristic of complex, nonlinear systems such as nature, society, and the economy, the neoclassical mainstream of economic thinking holds that everything in the economic system is reversible by definition, as reflected in the concept of weak sustainability.

The application of the concept of irreversibility in sustainability analysis depends on a number of factors:

- How critical the loss is to the overall system functions or productivity
- Whether substitutions for the loss are possible or desirable
- What compensations are needed to reduce the loss and the costs to the system
- What level of uncertainty is involved

The concept thus is not easily defined in scientific terms because it also depends on normative choices such as the social acceptance of compensation for degradation.

Defining irreversible limits to critical life support systems is a major conceptual challenge, as is the development of indicators providing early warning of the risk of irreversible damage. Setting such limits and predicting the risk for passing them are highly uncertain. Research has shown that the behavior of global systems such as biogeochemical cycles is characterized by thresholds and surprises (Steffen et al. 2002). Indeed, it was for situations with risk of irreversible damage that the precautionary principle was first formulated (EEA 2001). The Organisation for Economic Co-operation and Development (OECD) applies irreversibility only to ecosystems and the need to safeguard the natural processes capable of maintaining or restoring the integrity of ecosystems. Other areas of irreversibility may be difficult to define with the present state of knowledge and therefore are highly controversial.

Adding Meaning with Reference Values, Trends, and Targets

Indicators often are distinguished from raw data and statistics in that they are given meaning in relation to some type of reference value.[10] In the simplest case of two data points, the user interprets the trend indicated as positive or negative depending on the desired outcome. A reference value may be a baseline for which the indicator measures the distance to a meaningful state, such as a background value, standard, or norm. Or it can be a threshold value for irreversibility or instability, and the indicator measures the distance to a limit or point of no return. If a reference year has been set, the indicator measures changes over time related to that year, and a benchmark indicator measures differences between countries, companies, and so on. A reference value may become an explicit soft or hard target for policy, with distance-to-target indicators measuring the dis-

tance to the desired target or the limit to be avoided (see also Chapter 4, this volume). All types of reference values lend meaning and importance to data and therefore contribute to the function of indicators to communicate useful information.

Reference values are broadly accepted in such fields as health care, economics, environmental quality, climate change, and education. Physicians assess a patient's health by comparing measured values (e.g., blood pressure or blood sugar level) to baseline values corresponding to his or her sex, height, weight, and age. In the quality assessment of soil, water, and air, preindustrial background values play a prominent role. For biodiversity indicators, data on the number of species or the size of an animal population are meaningless without a baseline or reference value to which they can be compared, and there are a number of alternatives in this respect (Figure 2.1). A national species richness of 30,000 or a population of 1,000 dolphins is meaningful only when compared with a baseline value. The choice of that baseline is a normative and political challenge.[11]

A baseline in this context is not the targeted state. When policymakers have agreed on specific targets for an issue, they become another type of reference value to which indicators can be linked, such as the Millennium Development Goals (MDGs) (for a longer discussion of targets see Chapter 4, this volume). Most indices provide only relative rankings, as in country comparisons. Only the Environmental Vulnerability Index (Pratt et al. 2004) systematically proposes indicators referenced to specific parameters of environmental sustainability.

Avoiding "Data Drivenness"

Many indicator projects are driven by the availability of relevant and reliable data because indicators are useful only when there are sufficient data to give meaningful

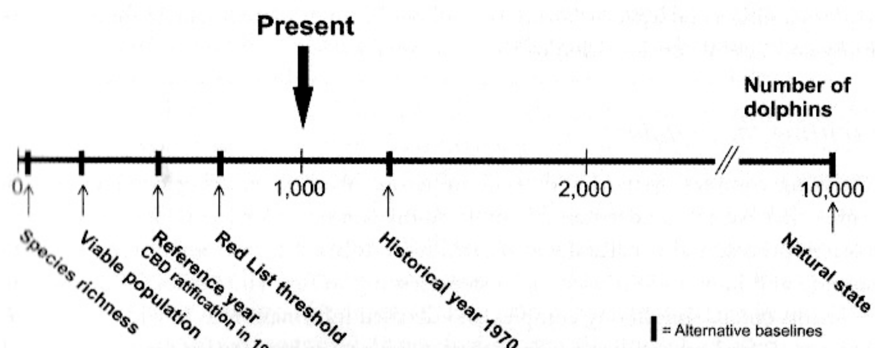

Figure 2.1. Six different baselines for one indicator value (1,000 dolphins present). A current population of 1,000 dolphins means different things when compared with historical data (1,300 in 1970), viability of the population (250), threat status (750) or the natural state (10,000) (Brink 2000).

results. In assembling indicator sets for sustainable development, data availability usually is a selection criterion to ensure rigorous quantitative underpinning. Even so, the limited quantity and quality of data underlying indicators of sustainability leave them open to criticism. Data collection is expensive, and countries are already under great pressure to supply data to international organizations from which they often receive multiple, overlapping, and uncoordinated requests for information. They are reluctant to accept indicators that imply new data collection.

This creates another conceptual challenge by producing biased and incomplete indicator sets that fall far short of measuring sustainability. We are forced to use indicators that were created for other purposes and describe only limited parts of the human–environment system. There are still extensive gaps in our knowledge, often reflecting inadequate supporting data. The result is both spatial and temporal bias. Scientific research and statistical data collection are strongest in industrialized countries, whose concerns and priorities dominate existing indicators.[12] Temporal biases come from the lack of long-term data sets and the concentration of most research on a very narrow time frame linked to the present.

It takes a long time to initiate new data collection processes, often 5–10 years, even in wealthy countries. Thus indicators being implemented now reflect issues identified at least 5 years ago. Finding the best indicators of sustainability entails breaking away from data availability constraints and determining the appropriate phenomena to monitor and the indicators needed. This implies switching from a deductive to an inductive research process. Data gaps can initially be filled with pilot collections and sampling, the use of remote sensing data, or the use of proxies (see Chapter 3, this volume).

Once development processes and sustainability issues are better understood and modeled with suitable indicators, it should be possible make data collection simpler and more flexible, for example with optimal spatial and temporal sampling, as a guide to institutionalizing long-term monitoring. However, changing data collection practices requires political and legal authorization and significant resources, calling for more flexibility and careful consideration of costs and benefits.

Limiting the Numbers

Analyzing complex systems and their properties involves reducing complexity to a degree that we can understand. Simplification is an accepted part of the scientific research process and is naturally associated with difficult choices about how much to simplify and how to do it without misrepresenting reality. The process of developing indicators entails simplifying complex and detailed information to provide communication tools for larger audiences. Specialists may be quite happy with a large number of indicators, but policymakers often request a single number for each problem to be dealt with. The latter may help policymakers attract attention but has limited usefulness in determining management action. The purpose and target audience determine the effective number of indicators, ideally the minimum necessary. At the same time, indicators of sustainable development should represent the large number of relevant issues. Selecting indicator sets and aggregating them into fewer indices are two of the most challenging aspects of indicator development.

Although few believe it is practical to develop just one aggregated index for sustainable development, incorporating all three pillars, there have been efforts to develop one index for each pillar. This still ignores the need for more systemic indicators linking the pillars that can provide higher-level integration. Any such cluster of highly aggregated indices has to be conceptually sound, with a supporting second layer of data that is easy to disaggregate, as demonstrated by the Dashboard of Sustainability, for example.[13]

Challenges in Process and Universality

The previous sections have amply demonstrated how many aspects of indicators involve normative choices or are biased by data availability. This raises questions about how indicators are developed, who is involved, and whose normative choices they reflect. Are indicators developed in one environmental, socioeconomic, and cultural setting valid in other settings? Can at least some indicators be universally applicable? The conceptual challenges raised by these types of questions require diligent efforts to make implicit value assumptions explicit and hidden biases visible.

Approaching the North–South Continuum

Countries are often compared by levels of development along a continuum from industrialized, developed countries (largely in the North) to the least developed countries (in the South). The size of this North–South divide and its increase over time are repeatedly confirmed by socioeconomic indicators in reports from various intergovernmental organizations. However, the conceptual challenge is to reflect the significant diversity of industrialized and developing countries in the design and selection of sustainable development indicators and determine how it affects their universal validity.

A number of indicators are clearly biased toward industrialized countries and their stage of socioeconomic development. In the economic domain, indicators such as GDP and income per capita are usually based on data for money flows generated through wage labor in the formal economy, partly because of the difficulty of defining and measuring nonmarket and subsistence activities. GDP has been repeatedly criticized for failing to incorporate the value of the informal economy, which constitutes a significant proportion of productive activity: 55 percent (Fukami 1999; Statistisches Bundesamt 1995, 2003), even in developed countries. In developing countries, the informal economy can reach up to 90 percent. The informal economy meets many development needs, such as child care, education, subsistence food production, water supply, fuel, housekeeping, handcrafts, and other domestic products. Where environmental conditions are good and traditional rural social and subsistence systems intact, the quality of life can be quite high, even in countries classed statistically as least developed. It would be valuable to determine how paid and unpaid work differ in their contributions to social, economic, and environmental sustainability.[14]

Another bias linked to the level of socioeconomic development lies in data availability and the effectiveness of statistical services. Most indicators originally were developed by industrialized countries, according to their own priorities, and reflect what they do best. Countries that are less developed economically may be more advanced in areas such as social cohesion or solidarity that are not captured in standard indicators. For example, an indicator of strong family relationships within and between generations would highlight the social and economic benefits of extended families, village communities, clans, and tribes, and the costs of the high divorce rates would be more important in countries without public health care and other welfare systems where people rely on these informal security systems.

The interpretation of indicators is often biased toward developed countries as well. For example, the number of cars in an industrialized country is usually used as an indicator of air pollution and consequent impact on human health. In a developing country, on the other hand, it may indicate improved access to markets and education. Different contexts may call for different indicators that have the same meaning. For example, coronary heart disease may be a more relevant health indicator in a developed country, whereas infant mortality may be more appropriate in a developing country.[15]

Recognition of this problem is leading to the revision of some indices. For example, the Growth Competitiveness Index of the World Economic Forum (WEF 2004), which has previously emphasized technological development, is being redesigned to reflect competitiveness at various stages of economic development.

Comparing Countries

Generally, peer pressure is considered a good thing among partners in any community, whether they be scientists, enterprises, or countries, if it leads to a healthy effort to strive for improvement and excellence. Comparison also helps to show what does and does not work and why. Many well-established national-level social and economic indicators and indices not only measure the development performance of a country over time but are also used to rank countries. For sustainable development indicators, there have been obstacles, both scientific and political, to the use of national-level indicators for worldwide country comparisons. The CSD indicators were explicitly endorsed by governments solely to measure each country's own sustainable development, by using a selection of indicators according to its own national priorities and circumstances, out of concern that intercountry rankings would be misused to impose conditions on development assistance.

Despite these concerns, good reasons remain for developing national-level indicators that allow country comparisons. All nations need to contribute to global sustainability.

The conceptual challenge is how to design indicators so that the comparison is legitimate and useful.

The approach to developing indicators suitable for intercountry comparison, whether at global or regional scale, should strive to

- Develop a sound, simple, and unified method for the selected indicators.
- Select indicators that reflect common agreed aspects of sustainable development or commonly agreed targets for action.
- Avoid indicators that are highly influenced by diversity in natural, socioeconomic, and cultural circumstances.
- Have full transparency of the whole process (development of indicators, methods, data collection, and presentation).
- Obtain agreement among the partners involved on the process, including public availability of results.

It is important to stress that indicators for intercountry comparison are only a complement to other indicator sets developed according to local, national, or regional priorities.

Reflecting Cultural Diversity

Different cultures usually have different views on what constitutes sustainable development. Such differences can be small variations in what types of economic or political policies should be adopted to promote sustainability, or they can represent significant divergences from the underlying development paradigm. This will influence both what a society would like to measure with indicators and which reference levels are seen as desirable or sustainable. The indicator sets most in use today are biased toward the dominant values of a Western-style market economy. For example, the reliance on GDP and related indicators reflects an economic development paradigm with a strong emphasis on the individual rather than the community and on material rather than social or spiritual dimensions of society, which may not be shared across all cultures.

This narrow focus also means that many aspects of society that are crucial to sustainability but are not part of the dominant political paradigm are absent in indicators. For example, there is a body of research on the importance of community values, such as trust and coöperation, for fostering collective action to manage common resources that could provide a basis for useful indicators (see Ostrom 1992).

The first challenge confronting indicator developers is to look again at the various indicator sets, particularly those used for intercountry comparison on sustainable development, to see whether significant cultural biases can be identified and made transparent, if not reduced. The second challenge is to develop indicators for a broader range of sustainable development issues identified within cultures that are largely underrepresented in the scientific and political debate on indicators.

Despite such cultural differences, there are still many values common to all human beings that should be reflected at the core of any indicator set. Everybody, regardless of culture, needs a minimum amount of food, clean water and air, shelter, space, health care, security, self-respect, social relations, respect for other living beings, and time, access, and opportunity to develop one's abilities.

The need to preserve the ecological balance of the world is also universal. The ability of diverse cultures and countries to agree on common values and priorities and to reflect them in indicators is exemplified in the Convention of Biological Diversity, where indicators to address different aspects of biodiversity at the ecosystem, species, and genetic levels were agreed on in 2004 (Conference of the Parties 2004). Although a common target is set for these indicators to achieve a significant reduction in the loss of biodiversity by 2010, countries are free to choose more ambitious targets. Another example is the MDGs and their derived targets and indicators for areas such as food, water, and health (United Nations General Assembly 2000).

Closing In on Equity

Global sustainability is a concept with solid physical limits, but sharing responsibility below that level is largely about how much is fair and for whom. Equity and justice are implicit in the sustainable development concept, both temporally in intergenerational equity, respecting the development needs of future generations, and spatially in intragenerational equity, stressing poverty eradication today (Chapter 19, this volume).

Most of the focus on equity and its measurement is at the lower end, at the extremes of poverty, focusing on the ability of people to meet basic needs. Less attention has been paid to the upper end of the equity continuum, the extremes of wealth and related overconsumption. For example, there are limited data on wealth at the national level, even for a proxy such as the number of millionaires, and few indicators of overconsumption (UNDP 1998). Because measurement often leads to management, there are strong incentives to ensure a lack of political attention on the issue of wealth.

National-level indicators that aggregate data into averages can hide significant inequity. National economic statistics are not easily disaggregated to measure equity along the gradients between rich and poor, urban and rural, men and women, and children and adults, or between racial or ethnic groups. The Gini coefficient captures income inequity within countries, and recent editions of the United Nations Development Program Human Development Report have highlighted aspects of social inequity (UNDP 2004). However, the conceptual challenge is to develop a range of indicators that capture the equity dimension of sustainable development.

Closing In on Democracy

The concept of participation and majority decision making expressed in the term *democracy* is related to equity. Although democracy may be interpreted differently in various intercultural contexts, there is a claim for democracy as a universal principle for institutionalizing sustainable development. This can include access to and participation in processes of generating knowledge, developing indicators, and using them to guide action. There is a risk that certain ideas become embedded as authoritative in the conceptual framework and governance of sustainable development, whereas others are marginalized. Given the normative dimensions of indicators and the biases they contain, democratic processes are particularly necessary to ensure access to and inclusion of different types and sources of knowledge in indicator development (Berkhout et al. 2003:25). This entails engaging scientists and users from a much broader spectrum of countries (particularly developing countries), cultures, and disciplines (see Chapter 4, this volume).

Multistakeholder processes of dialogue, decision making, and implementation are increasingly institutionalized across governance levels, as in local Agenda 21 roundtables, the practices adopted by the CSD, and the emphasis on partnerships at the WSSD (see UNCED 1993; United Nations 2002; CSD 2004). Principle 10 of the Rio Declaration outlines the right of access to information, participation, and justice embodied in the Aarhus Convention.[16] Although there are indicators designed to account for the degree of implementation of democratic principles, most developed by nongovernment organizations such as the Corruption Perceptions Index (Lambsdorff 2003), the International Standards of Elections (OSCE 1990), the Worldwide Press Freedom Index (Reporters without Borders 2004), and key indicators for the violation of human rights (Amnesty International 2004), the challenge remains to develop indicators for democratic practice concerning sustainable development.[17]

Winning Acceptance

The need for indicator users, particularly decision makers in political processes, to agree to and take ownership of sustainable development indicators creates its own conceptual challenge. Politicians, corporate executives, and many other senior officials can retain their positions only if they are seen to do well. Any indicator that reflects well on their performance will be supported, but indicators that show they are doing badly will meet strong opposition or rejection. In the current state of the world, most indicators of sustainability show how unsustainable present trends are. Given the proverbial tendency to shoot the messenger bearing bad news, it is very difficult to win acceptance for indicators that reflect negatively on the performance of decision makers. Only a careful indicator development process, and often peer pressure from others who support the process or from a demanding electorate, can win reluctant consensus to adopt and use sustainability indicators. The process itself must be seen as transparent, inclusive, fair, and legitimate, and strive to be independent of pressures from narrow organizational or personal self-interest, if it is to succeed.

Conclusions

This review of the conceptual challenges in developing indicators of sustainable development shows both progress made and work remaining. Table 2.2 assesses the stage of development of existing indicator efforts to meet each conceptual challenge discussed in this chapter.

Some indicators are ready for use, such as for linkage between economy and environment, economic equity, and certain efforts to consider the spatial aspects of sustainability. Most challenges still need further research and development, including the following:

- Developing indicators for global sustainability and planetary limits
- Completing indicator sets for each pillar with reference values
- Continuing to develop linkage indicators between pillars
- Exploring alternative models for understanding the sustainability of systems and indicators of system characteristics
- Interrelating different temporal and spatial scales, especially the short-term economic and long-term environmental perspectives
- Correcting the balance of indicators relevant to countries' stages of development and cultural diversity
- Distinguishing the objective and normative components of indicators and developing indicators for dimensions such as equity and participation

The significant progress over the last decade has made it possible to focus more precisely on the remaining conceptual challenges and to define some ways forward. Many indicators relevant to sustainable development have been assembled, and although many gaps remain, it is already possible to start addressing the key issue of integration. Economic, social, and environmental subsystems interact so fundamentally that all must be considered together in an exploration of feasible pathways toward sustainable development. In particular, successful governance for sustainable development depends on an appropriate analysis of these links.

A system perspective alerts us to the complex and often nonlinear character of these subsystems, to the existence of thresholds for irreversible switching from one stable system state to another, and to other surprises that are difficult to unravel and even more difficult to predict. Thus, a system perspective implies a more humble approach to governance, recognizing the limits of our ability to fully understand and control the impact of policies and actions. It encourages us to use indicators in a more responsive learning mode, acknowledging the need for wide participation in adaptive management to achieve the dynamic state that is sustainability.

Table 2.2. Stage of development in indicators to meet conceptual challenges.

Sustainability			Process and Universality		
Challenge	Stage of Development		Challenge	Stage of Development	
Measuring sustainability and sustainable development	In general	I	North–South issues	For strengths of countries	I
	Some indicators capturing some components of sustainability	II		For Northern development bias	II
	Biodiversity indicators	III		For indicator definitions	III
Frameworks		II	Country comparability		III
Linkages between pillars	Economy–environment linkage	III	Cultural diversity	International	I
	Social–environment linkage	I		National (some countries)	II
Temporal and spatial scales	In general terms	I	Equity	Environmental equity	I
	In individual cases	III		Social and institutional equity	II
				Economic equity	III
Strong–weak sustainability	Where applicable	I	Democracy		II–III
Planetary limits		I	Acceptability		II
Vulnerability–resilience	Environmental systems	II			
	Social and economic systems	I			
Irreversibility		I			

Note: The stages of indicator development are classified as follows: I, research stage; II, in development, some progress made; III, ready for implementation.

Notes

1. See Spangenberg (Chapter 7, this volume) for a detailed discussion of the institutional dimension of sustainable development and related indicator developments. See also Spangenberg et al. (2002) and Spangenberg (2002).

2. For indicators in use, see Rosenström and Palosaari (2000), UCR and MINAE (2002), and the list of indicator Web sites in the Annex.

3. A prominent example of indicators developed within this framework is the decoupling indicators, focusing on the links between the driving force and pressure component (Chapter 13, this volume). This can refer to pressures on the environment from material and energy flows and land requirements, as in the Geobiosphere Load Index (Chapter 14, this volume). Haberl et al. (Chapter 17, this volume) argue for pressure indicators for biodiversity loss and describe one example of a comprehensive pressure indicator to meet this need. For health, a modified framework of driving force, pressures, state, exposures, health effects, and actions (DPSEEA) has been applied (Chapter 15, this volume).

4. These scales are expanding with globalization. Jesinghaus (Chapter 5, this volume) discusses indicator approaches to measure various aspects and impacts (good or bad) of globalization.

5. Eisenmenger et al. (Chapter 12, this volume) discuss how global domestic extraction of raw materials can be related to specific scarcities such as global net primary production of biomass.

6. See Eisenmenger et al. (Chapter 12, this volume) for a detailed description of the approaches to make material flow analysis take into account transnational material flows and Moldan et al. (Chapter 14, this volume) for a similar introduction to energy flow analysis.

7. It is also closely associated with the evolution of the term *natural capital* (Victor 1991). Knippenberg et al. (Chapter 19, this volume) explore the concept of capital in discussions on sustainable development and show the normative implications of its use.

8. Zylicz (Chapter 6, this volume) discusses the value of greening GDP as a way to improve social welfare measures without having to assign relative weights to various aspects of well-being, which is often done in sustainable development indices.

9. Domestic extraction of raw materials (DE), when measured in DE per unit GDP at the global level, expresses the overall material intensity of the total human economy (Chapter 12, this volume).

10. The EEA database on Sustainability Targets and Reference Values contains definitions and links (star.eea.eu.int/default.asp).

11. Biggs et al. (Chapter 16, this volume) outline the baselines that have been proposed for biodiversity indicators by the Convention on Biodiversity.

12. Indeed, there are significant gaps in data collection for indicators in many OECD countries, such as for decoupling indicators (Chapter 13, this volume). For a discussion of the divide between the North and the South in scientific capacity in general and environmental knowledge production in particular, see Karlsson (2002).

13. See esl.jrc.it/envind/dashbrds.htm and Jesinghaus (Chapter 5, this volume) for information on the Dashboard of Sustainability. Bauler et al. (Chapter 3, this volume) discuss the methodological challenges of aggregation in more detail.

14. This difference has clear gender dimensions, for example in how society values reproductive and caring work (Chapter 7, this volume).

15. von Schirnding (Chapter 15, this volume) discusses environmental health indicators in more detail.

16. The full name is the Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters (www.unece.org/env/pp).

17. Jesinghaus (Chapter 5, this volume) lists some democracy-related indicators in a cluster called "Culture and Governance."

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3

Identifying Methodological Challenges

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The methodological challenge in deriving indicators for sustainable development lies in constructing indicators that are accurate representations of environmental or societal states or trends but are easily understood by their target audiences. Methodological challenges thus involve two broad sets of questions: those concerned with the design and development of indicators and those concerned with the purpose and use of indicators. Basic concerns over data availability, data quality, and the adequacy of the algorithms used can be resolved largely through technical, scientific agreement. However, the central issue of adjusting methods to indicator relevance and use has to be addressed through trade-offs between form and function in specific societal and political settings.

Constructing a sustainable development indicator raises such methodological issues as the multidimensionality of domains, the complexity of the socioenvironmental system under scrutiny, and the presence of cross-scale (both temporal and spatial) effects and impacts. The translation of these issues into coherent procedural and substantive methods largely determines the formal quality of the assessment tool.

The use and purpose of the indicator are part of the process of developing awareness of sustainable development (i.e., contributing to the self-generation of sustainable development; see Chapter 1, this volume), essentially an iterative process wherein new indicators are developed, tested, reformulated, and improved as a result of interaction with and feedback from users in all walks of society. This chapter concentrates on the methodological challenges in the development of indicators. First we break sustainable development down into a hierarchical setting of subdomains necessary for the con-