PART IV
System and Sectoral Approaches
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The progress being made in assessing sustainability can be illustrated best through some examples of specific indicators and indices measuring key properties or processes in the human–environment system. These indicators help to define significant dimensions of sustainability more clearly, often in a way that is directly relevant to policy targets or that highlights areas for management action.

Chapter 12, "Indicators of Natural Resource Use and Consumption," shows the usefulness of material flow analysis to give a more systemic view of the operation of the economy. Instead of looking at the flow of money, as in gross domestic product (GDP), material flow analysis measures the physical movement of materials and the resulting mass balances as raw materials, products, and wastes are transferred from place to place. Because certain environmental impacts are strongly linked to natural resource extraction and waste disposal, this analysis and the indicators it generates are useful to assess the environmental impacts of economic activities. By looking at domestic extraction rates and trade balances in physical terms, it can illustrate the extent to which a country may be exploiting its natural resources unsustainably or exporting its environmental burden. Because most materials become wastes sooner or later, it can illustrate the waste potential created by certain activities and facilitate waste management or reduction. It can also account for materials accumulated in stocks and infrastructure. The right material flow indicators can measure efforts to decouple economic progress from material consumption, with increased resource productivity and recycling and the dematerialization of the economy.

In Chapter 13, indicators that measure the decoupling of environmental pressures from the relevant economic driving forces are further explained. By tracking temporal changes, these indicators aim to reduce environmental pressures and to encourage decoupling from specific environmental impacts. Although relative decoupling can signal a desirable trend, absolute decoupling is usually necessary to achieve sustainability. Because decoupling indicators tend to change over shorter time periods than environmental state indicators, they can be particularly useful for assessing policy effectiveness. By linking such indicators to decoupling targets, we can produce performance standards for products.

Taking this approach a step further, Chapter 14 proposes a Geobiosphere Load Index. This index combines material flow analysis, energy flow accounting, and a modified form of the ecological footprint concept, including indicators of input, output, and consumption, to assess human pressures on the environmental capacities of materials, energy, and land and thus on related ecosystem services. Such an index could be calculated per square kilometer, per capita, or per unit of GDP for resource efficiency. Although this is still work in progress, it provides a simple, easily understood measure of fundamental dimensions of sustainability.

As one example of the use of indicators in a specific field, the health sector demonstrates how indicators are playing an increasingly important role in communicating complex health and environment information. Chapter 15 reviews the use of health and environment indicators in support of sustainable development, emphasizing indicators of the linkages between environment and health at the national, sectoral, and community or neighborhood levels. Early attempts to simplify information for policymakers and the public included a driving force, pressure, state, exposure, health effect, action framework, but this was found to be too linear and oversimplified and thus potentially misleading. Core indicators with harmonized and rationalized methods are being developed to lessen reporting burdens and to facilitate between-country comparisons. The World Health Organization has developed indicators and targets to measure policy and program implementation and to support the World Health Report. Environmental health indicators are particularly useful in sustainable development planning and in supporting regional health information systems. A recent focus is on children's environmental health indicators in a more flexible model that takes into account multiple exposures. All such efforts face limitations in the available data, necessitating further development and harmonization of data collection and processing. The key future challenges for health and environment indicators include scale, capacity, data comparability, and reliability.

For another sectoral approach, Chapter 16 provides a comprehensive review of the status of biodiversity indicators, including the basic concepts, current developments, and future possibilities. Responding to the international target to reduce biodiversity loss and the need to measure the effectiveness of measures adopted under the Convention on Biological Diversity, recent indicator work has generated a certain number of trial indicators in a field suffering from inadequate data, great complexity, and poor understanding of the causal links between biodiversity and ecosystem services. The present conceptual framework combines three levels of organization (ecosystem, organism, and gene) with three aspects (composition, structure, and function). There are still problems in establishing a baseline for biodiversity loss, measuring richness and evenness, and finding proxies for immediate use where the information is inadequate. Although rapid

progress is being made in studying biodiversity at the genetic level, it will be some time before indicators can be developed at this level, complementing the present species-based indicators.

Among the most common biodiversity indicators in use, species richness is the most widespread, but like endemism it is not good for measuring loss. Species extinction is an easy indicator to understand but difficult to prove in practice. Population abundance–based indicators in theory can give the necessary early warning of biodiversity loss, but they generally lack the time series data to do so. Area-based indicators, such as the area of ecosystems and the extent of fragmentation, can address abundance at the ecosystem level but suffer from methodological problems that produce inconsistent data and an absence of long-term time series. Chapter 16 describes other still embryonic approaches, including phylogenetic and evolutionary indicators, functional indicators, integrity indicators, and various composite indices. Where there is no information on biodiversity trends, indicators of pressures that are correlated with biodiversity loss can be used instead, as demonstrated in Chapter 17. For policy-relevant indicators, there is a mismatch between the available information primarily on species composition and the policy concern to conserve the functional attributes of ecosystems.

The chapter addresses data issues by recommending a more pragmatic approach, focusing on well-known groups and using qualitative and informal as well as quantitative information. The immediate need is for land cover and use, the distribution of plants and vertebrates, trends in the populations of key species, genetic diversity within domesticated species, and the impacts of land use on species. Significant gaps on which research should focus include the functional relationships between biodiversity and ecosystem services, predictors of the consequences of human activities, genetic relatedness and redundancy, maps of land use and species distributions, historical ecology to provide baselines, and the establishment of biodiversity observation and assessment systems.

One example of an aggregate process-oriented indicator highly relevant to sustainability is the human appropriation of net primary production and the pressure it exerts on natural biodiversity, as described in Chapter 17. This pressure indicator is defined as the alteration in primary productivity from human land use (the productivity prevented) plus the human extraction of net primary productivity (the biomass harvested), giving the difference between the potential vegetation and the part remaining after harvest. It serves as an aggregate indicator of human-induced changes in ecosystem processes and therefore of human domination of terrestrial ecosystems. Its significance for sustainability is shown by the estimate that 40 percent of global terrestrial primary productivity is appropriated for human uses. The indicator is linearly correlated with the natural state of landscapes and shows a high correlation with species richness, making it a good pressure indicator for biodiversity loss. It is also relevant for carbon stocks and flows in ecosystems and can be related to economic activities, consumption, and GDP. The human appropriation of net primary production is thus an excellent candidate for a set of sustainability indicators.