10

Integrated Assessment and Indicators

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Of all the potential uses of indicators of sustainability, integrated assessment is perhaps the most critical and also the most difficult because such assessments must bring together a wide variety of issues and topics. An assessment is by definition an evaluation, and indicators are one way of expressing the absolute or comparative value of something. In the context of sustainability, an assessment evaluates and draws conclusions about the state of and trends in some unit or component of society or the environment and its future perspectives. This component could be a local community, a corporation, an ecoregion, a nation, a continent, or the entire planet. This review focuses on international assessments, but the same principles apply at other levels. Various kinds of statistics, data sets, and indicators can serve as the basis for such assessments. An integrated assessment for sustainability involves a comprehensive consideration of the economic, social, environmental, institutional, and other relevant aspects of the entity, including the relationships between all these factors. In practice, our limited understanding of such complex human–environmental systems means that our assessments fall short of the ideal of full integration, and the issues may just be juxtaposed. There has been no comprehensive evaluation of the various attempts at integrated assessments, but the International Council for Science has proposed such a review (ICSU 2002).

This chapter explores the practice of and challenges in the use of indicators in integrated assessments, both to measure the states and trends in various components and, ideally, to indicate the behavior of the whole integrated system and its implications for the future. In this latter role, these would be true indicators of sustainability. The emphasis is on progress since the last review of the state of the art in sustainability indicators by the previous SCOPE project (Moldan et al. 1997). A very useful analysis and evaluation of recent efforts to produce more integrated indices has been prepared (in French) by Gadrey and Jany-Catrice (2003). It highlights the progress now being made

to produce indicators that begin to integrate over broad economic, social, and environmental areas.

At present, integration using indicators has followed two approaches: broad aggregations of indicators or indices that combine indicators across multiple sectors but do not analyze interactions and integration focusing on dynamic system behavior over time and the interrelationships between factors. Because of the difficulty of the latter, integrated assessments today have almost exclusively used the former, and it is those examples that are reviewed here. However, the challenges of climate change are pushing climate modelers to extend their computer models with an increasing number of environmental, social, and economic dimensions, which should accelerate future progress in integrated modeling. The end of this chapter includes some suggestions for future work on more dynamic and complete forms of integration to assess long-term human sustainability.

Scientific Validity of Definitions

Assuming that an integrated assessment is intended to report on sustainability, the most important and difficult definition is that of sustainability itself. Sustainability is not a goal to be achieved at some point in time but a characteristic of a dynamic human–environmental system able to maintain a functional productive state indefinitely (Dahl 1996, 1997a). Integrated indicators of sustainability therefore should measure the functional system processes that best represent its capacity to continue far into the future. Defining sustainability in terms of durability over time avoids the problem of specifying the characteristics of the system or entity to be maintained, which can be very subjective and specific, and where political, philosophical, and cultural differences can prevent any wide consensus. The optimal sustainability indicators are those that best show a scientifically verifiable trajectory of maintenance or improvement in system functions. Although the choice of indicators depends on the system in question, it is not their substance but their dynamic change over time that is important for measuring sustainability. Science cannot always validate the goals set for the system, but it can validate the ability of the indicators chosen to measure the trajectory toward those goals or the reduction in damaging factors threatening the system's sustainability.

Scientific approaches can also help us understand or model the complex operation of the system and thus ensure that the indicators selected reflect its most essential characteristics and are able to measure its sustainability within the limits of predictable system behavior.

Although sustainability assessment is needed most often in the context of sustainable development, and most integrated assessments specifically aim to do this, the concepts are not synonymous. The term *development* is often erroneously equated with growth, which by definition is not infinitely sustainable in a finite system. Sustainability requires the redefinition of development to mean improvements in human welfare and prosperity, including poverty reduction but respecting planetary limits, which may entail limited growth in some areas and perhaps reductions in consumption in others.

History and Existing Use

There are two fundamental starting points for linking integrated assessments and indicators based on two approaches to assessment. One uses expert opinion or consultation with stakeholders to produce an integrated assessment in text form and then develops indicators to explain, illustrate, and eventually complete or extend the results of the assessment. The second, more statistical approach is to assemble a set of indicators or statistics in some coherent statistical framework to produce a more numerical integrated assessment. Perhaps at some point in the future the two approaches will converge, but at present they involve different communities of natural and social scientists or statisticians.

Assessments with Indicators

Sampling of the principal integrated assessments at the international level illustrates the different ways indicators are being used today and the significant progress that has been made in the last decade. In most cases, the indicators are illustrative, providing numerical and graphical support to reinforce a text-based assessment. Generally such indicators are used only where good data are available, and many parts of the assessment may have little or no indicator support for this reason. Some assessments have been prepared by a one-off process producing a single report, and indicators for these are limited to the data available at the time. Other continuing assessment processes generate periodic reports. Where efforts are being made to build comprehensive and comparable global data sets as part of the assessment process, the number of indicators used in such reports is increasing.

The problem is that there are few compilers of globally consistent data sets or indicators, including the United Nations and its agencies (e.g., the Food and Agriculture Organization, United Nations Development Programme [UNDP], United Nations Environment Programme [UNEP], World Health Organization, World Meteorological Organization), the World Bank, the Organization for Economic Co-operation and Development (OECD) for its member countries, and a few national or nongovernment institutes (e.g., The Netherlands National Institute of Public Health and Environment, World Resources Institute).

A good illustration of the challenges of using indicators is the UNEP *Global Environment Outlook* (*GEO*) report series of integrated assessments. The first *GEO* report in 1997 (UNEP 1997) was largely qualitative in its assessments. Even illustrative data tables were limited to selected countries. The only use of a few indicators was in the scenarios giving some projections to 2050, which looked at regional changes in population,

gross domestic product (GDP), primary energy consumption, energy intensity, agricultural production (maize), caloric intake, total water withdrawal, changes in land use and cover, and habitat loss. By *GEO 2000* (UNEP 2000), some indicators were given at the global and regional levels for the assessment of selected problems. In addition to the indicators used in *GEO 1*, these included cropland per capita, hunger, forest area, fishery production, carbon emissions, toxic waste, and urbanization. Many of these indicators were produced by one-off studies and did not present time series or trends. By *GEO 3* (UNEP 2002), the effort to develop the data necessary for globally consistent indicators for assessments began to show results. Nearly every page includes text and one or more indicator tables or graphics showing states or trends. However, the indicators used still measure specific problems or social or economic trends and do not attempt an integrated view of system behavior. The indicators are not really the tools for the assessment but illustrations with a function similar to photographs.

Other international assessments suffer from similar handicaps. The *Global Outlook 2000* (UN 1990) assembled chapters on various economic, social, and environmental trends illustrated with graphs and tables of selected indicators but with no integration across the sectors. Most global assessments follow the general model of the World Bank (2004) *World Development Report* with text-based assessments illustrated with a few indicators in graphs or tables, followed by tables of world development indicators by country. Such extensive data tables are useful for experts and have helped support many other assessment processes. They inspire confidence in the preceding assessment by emphasizing its quantitative scientific basis. However, they have little direct public impact, showing that too much numerical information without a framework to provide coherence and orientation has no meaning (Gadrey and Jany-Catrice 2003). The long history of economic indicators has allowed highly integrated indices such as the GDP to evolve, but there has been little effort to integrate beyond the economic sphere.

Even the assembly of such data tables suffers from serious problems of data gaps and inconsistencies, which make the production of indicators with sufficient consistency to permit integration a time-consuming and costly process even where it is possible. Few organizations can afford to do this, and once such data are made available, they are often endlessly and sometimes uncritically recycled from assessment to assessment.

The *World Resources* reports (UNDP, UNEP, World Bank, and World Resources Institute 2003), issued every 2 years, are among the most data- and indicator-rich global assessments, with analytical text and selected indicators combined with extensive data tables. Like the UNDP *Human Development* reports, each report develops a specific theme with data and indicators relevant to that theme. However, the data tables are relegated to the end of the report, and, if anything, the use of indicators has declined in recent years in favor of other forms of graphic communication and summary text. The UN Division for Sustainable Development prepared a *Critical Trends* report for the 5-year review of Agenda 21 (UN DPCSD 1997). Although it surveys the long-

term trends in selected environmental and socioeconomic issues illustrated with appropriate indicators, it does not integrate them in any systematic way.

The report *Protecting Our Planet, Securing Our Future* (UNEP, NASA, and World Bank 1998) was a one-off attempt to identify and integrate the key scientific and policy links between major global environmental issues and between these issues and basic human needs. It uses a selection of indicators to show present environmental impacts and projected future trends, but again these are illustrative rather than the basis for integration.

Another approach is to build an assessment around important statistical trends, with a compiled index of several indicators as the central theme and attraction of the assessment, amplified by additional text, indicators, and data tables. The best example is UNDP's annual *Human Development Report* (UNDP 2004), which aims to get countries to focus on key issues of human development. The report makes headlines and attracts high-level political attention because it ranks countries with its Human Development Index (HDI). This simple index, combining only a few basic statistics (life expectancy, adult literacy, school enrollment, GDP per capita), was initially quite controversial but has had great impact. It is significant more as a communication tool to motivate countries to reexamine the impact of development on people rather than a truly integrated measure of sustainable development. It attracts people to read the report and to consider the other data tables and thematic analyses that amplify the basic message (Sen 1999). The annual thematic assessments provide an integrated view of key human development issues, but again the indicators are used just to support the text. They are illustrative rather than tools in themselves for integration.

These examples show a pattern of increasing use from scattered illustrations to an index as the flagship of the assessment, but the indicators still play only a supporting role rather than defining the behavior and sustainability of the human–environment system.

Assessments Based on Indicators

The second approach to integrated assessment has built on the long work of statisticians and economists to assemble integrated and coherent national economic accounts. Gadrey and Jany-Catrice (2003) have reviewed in detail the recent efforts to extend this work into indicators of wealth and development. This approach starts by compiling many different statistics and indicators into a comprehensive data set. The challenge of this approach is to identify a realistic and balanced set of indicators and to collect sufficient reliable data to avoid so much interpolation or estimation that the results are meaningless. As with the illustrative indicators in the text-based assessments, a compilation of indicators can demonstrate many facets of the problem but does not actually integrate them. Here the issues of selection and weighting become crucial, and there is no consensus on a scientifically valid solution. This approach is still at the stage of a better description of the present state of the economy and society and sometimes the reconstruction of past trends. Less work has been done on the potential to project such

indicator-based assessments into the future to determine sustainability because this will require complex and conceptually challenging models. A few examples will illustrate the present state of the art.

Gadrey and Jany-Catrice (2003) cite the Index of Economic Well-Being developed by Osberg and Sharpe (2002) as the most methodologically sound of the integrated indices while combining both objective and subjective measures. It equally weights four components: consumption (market consumption per capita, government expenditure per capita, unpaid domestic work), wealth (physical capital per capita, R&D per capita, natural resources per capita, human capital and education, minus net exterior debt per capita, minus cost of environmental degradation), equality (poverty, Gini coefficient of inequality), and economic security (risk of unemployment, economic risk of illness, poverty risk in single-parent families, poverty risk of older adults). Some of the factors are only roughly estimated, but because the index measures change over time, the absolute values are less important than relative changes from year to year. The index is also insensitive to changes in weighting. The plots of this index and its components over time show that GDP per capita and well-being do not always correlate, and even between industrialized countries, the performance on the different components can vary widely. Although the focus of this index is economic, it includes social and environmental dimensions. It does not attempt to measure sustainability, but methodologically it shows what might be possible.

The World Economic Forum and Yale and Columbia Universities developed an Environmental Sustainability Index (ESI) as the basis for their report *Environmental Performance Measurement: The Global Report 2001–2002* (Esty and Cornelius 2002), recently updated in the *2005 Environmental Sustainability Index* (Esty et al. 2005) comparing the performance of 146 countries. The ESI is made up of twenty-one indicators and seventy-six variables. It is probably the environmental assessment that most directly uses indicators as the tool for its evaluation. However, the reliance on indicators did not reduce the subjective dimension of the assessment, which was simply reflected in the selection of indicators and the weighting method chosen. Widespread criticisms of the 2002 ESI led to significant modifications in the 2005 version, which also identified further improvements that would be desirable when the data permit. The index also aims only to provide an integrated measure of environmental sustainability and does not attempt to address economic or social sustainability.

The UN Commission on Sustainable Development work program on indicators has produced two compilations of methods for sustainable development indicators (UN DSD 1996, 2001) for use at the national level. These have conceptually attempted to provide the basis for integrating many dimensions of sustainable development as defined by governments in Agenda 21, but they have not actually been used to generate integrated assessments, leaving that responsibility to national governments. Governments have indicated that they did not want such indicators used to compare and assess their sustainable development at the international level out of fear that this might lead to conditionality in development assistance. However, the Commission on Sustainable Development (CSD) indicators is the only set benefiting from such high-level political acceptability through their trial by many governments and adoption by the CSD. The first trial set of 134 indicators was arranged in a driving force, state, response framework and grouped by chapters of Agenda 21 (UN DSD 1996). This could have provided the basis for integrating the indicators according to their roles in system sustainability, but the indicators were too few and disparate for such integration, and the framework served only to show how well key issues of sustainability were being covered. The second set of 58 core indicators (UN DSD 2001) aimed to show their policy relevance by clustering them by themes and subthemes. This strengthened their power to communicate but was less amenable to an integrated view of sustainability.

Examples

Building on the CSD and other work, the Consultative Group on Sustainable Development Indicators (CGSDI) (iisd.org/cgsdi/) has assembled a data set corresponding to the CSD indicators and developed an interesting tool, the Dashboard of Sustainability (esl.jrc.it/dc/index.htm), that provides an integrated presentation of such indicator sets. The CGSDI thought that integrating across economic, social, and environmental fields was conceptually difficult because there was no common denominator, but that economic indicators with monetary values, social indicators expressed per capita or in similar human terms, and environmental indicators based on scientific measurements could be integrated within those sectors and then cross-compared for a more complete view of sustainability. The result is not an assessment as such but a means by which each user can perform individual assessments. Because the Dashboard is a tool for an integrated view of any data set, it can be used to compare different indicator sets and to highlight and make transparent the assumptions and weightings, conscious or unconscious, behind each. It can therefore facilitate more open integrated assessments.

An interesting recent initiative to address sustainability more directly is the Environmental Vulnerability Index (EVI), developed by the South Pacific Applied Geoscience Commission (SOPAC) (Kaly et al. 2003; Pratt et al. 2004; SOPAC 2005). This uses fifty indicators to estimate the vulnerability of the environment to future shocks in 235 countries (www.vulnerabilityindex.net/). What is conceptually interesting about this index is its effort to relate the indicators to scientifically founded concepts or limits of what is sustainable rather than to simply give the range of countries from best to worst. The index is reported as a single dimensionless number, accompanied by several subindices and a country profile of the results for all indicators, showing where the specific problems lie. The index thus integrates and assesses all aspects of environmental vulnerability. Although there are still aspects that need refinement, the EVI approaches an integrated measure of environmental sustainability. It is intended to accompany another index of economic vulnerability also developed in the context of the 1994 Bar-

bados Programme of Action for Small Island Developing States, which called for the development of a vulnerability index.

Nongovernment organizations have developed their own assessment approaches and reports in an effort to provide an alternative view to that of the official or dominant view of governments and economists. Some of these have pioneered integrated indices as the principal instrument for their assessments, supported only by short text commentary. A good example is the annual WWF *Living Planet Report* (WWF 2004). It includes a Living Planet Index averaged from indices of global terrestrial, freshwater, and marine species and a World Ecological Footprint compiled from cropland, grazing land, forest, fishing ground, and energy footprints. It also includes scenarios projecting key indicators into the future. *The Wellbeing of Nations* (Prescott-Allen 2001) is another example of an assessment of nations' environmental status and quality of life based on several highly aggregated indices. However, it would best be described as a status report rather than a sustainability assessment.

As these examples show, although indicators are becoming increasingly common in integrated assessments, they are still largely illustrative of specific factors or the comparative state of such factors and are far from reflecting or driving the integrated perspective itself or capturing the dynamic processes underlying sustainability. However, some recent initiatives are beginning to make progress in that direction.

Methodological Aspects

The use of indicators in integrated assessments faces the same challenges as with other uses of indicators: selection of appropriate indicators, data availability, comparisons between disparate topics and forms of measurement, weighting, and total and relative numbers of indicators selected (which often implies an inherent weighting). In addition, there is the challenge of integration itself: finding indicators that reflect the whole and not just the parts. In the present state of the art of integrated assessment, this question has not yet been resolved. One approach will be through complex computerized system models that mathematically reproduce the structure and dynamics of the system. As assessments come to be based on such models, as is now at least partly the case for climate change assessments, indicators can be derived from the models to reflect system resilience, susceptibility to perturbation, and ability to maintain basic functions and outputs over long time periods. Once these new indicators of system performance and sustainability have been validated by such models, they can be implemented with models driven by real data streams.

Some specific types of indicators have an integrating aspect useful for integrated assessments, such as indicators of material flows (Adriaanse et al. 1997), energy intensity, and decoupling of resource inputs from outputs. Indicators that show vectors of trends toward or away from a sustainable state or convergence with a target can also be helpful (Dahl 1997b).

One of the most difficult aspects to treat in a methodologically and scientifically rigorous way is the underlying assumptions guiding the assessment and therefore the selection of indicators. Different individuals, organizations, sectors of society, and cultural groups have their own worldviews, visions of the future, perspectives, and values. There is an inherent tendency to select indicators and make assessments that validate a preconceived view of the world or confirm inherent biases. Such assessments tend to be more popular and influential and receive acceptance in policy circles not because they are scientifically valid or right but because they say what people want to hear. An indicator set that reflects the views of corporate leaders in a materialistic, free enterprise economic system will be very different from one prepared by environmental groups or social activists in undeveloped countries.

The methodological challenge is first to make these different perspectives and biases transparent and then to separate the normative dimension of sustainability from the scientifically verifiable trends in that particular context. Integrated measures of the sustainability of a system for warfare or development assistance should be possible without moral judgments about the goals of the activity. After all, the integrated index of gross national product was first developed to measure the American war effort. Once indicators of system behavior and sustainability have been developed, it will be necessary to try to step outside the context of the various dominant worldviews and to judge sustainability with respect to planetary limits, at least for the factors that can be established scientifically. This scientific perspective on sustainable limits can then be reintegrated transparently with value judgments about the choices to be made to keep the human economic and social system within those limits.

Relevance to Sustainable Development

As the state of the art in integrating indicators progresses, synthetic indices combining many indicators will become increasingly relevant as the basis for assessing and communicating sustainability. At present, the assembly of increasingly comprehensive data sets of indicators covering the state of and trends in economic, social, and environmental factors relevant to sustainability provides a first approximation of where we are and where we are going. However, these data sets do not capture the interactions between factors and the broader dynamics of the system that are critical to sustainability.

One important issue is the distinction between development, as commonly understood, and sustainability. Development often is equated with growth, whether in wealth and economic activity, infrastructure, or institutions. However, where growth has pushed a society beyond sustainable limits, long-term sustainability may entail a reduction in certain economic activities, technologies, or resource uses and a simplification in lifestyles (Meadows et al. 1992). This entails a broader vision of human development that may combine higher levels of social integration, culture, science, and the arts with a more moderate approach to the material side of life. Care must be taken to select indi-

cators of sustainability that capture all the dimensions of a rich and rewarding human society contributing to social and human sustainability, not just the material aspects of sustainability on this planet.

Policy Relevance and Legitimacy

Most recent integrated assessments give a high priority to policy relevance and ensure that issues of concern to policymakers are explicitly addressed. The use of extensive supporting data tables and indicators increases their legitimacy by demonstrating the objective foundations of their analyses. However, such data tables by themselves will have little direct impact on decision makers, who need simpler and more explicit indicators of sustainability to communicate the key messages. The HDI is a good example of a simple indicator that reaches policymakers and opens the door to a more detailed consideration of underlying causal factors. The HDI leverages much greater impact from the whole *Human Development Report* (Sen 1999). Integrated assessments should aim to have both detailed indicators of key problems and trends for specialists and technical advisors and one or more flagship indices that will attract the attention of policymakers and the media.

The real problem is that the best-integrated assessment based on substantial data is still not sufficient to convince the major actors in society, whether in government or the private sector, to look beyond their immediate short-term interests. Sustainability is inevitably a long-term issue. There are rarely problems that threaten our very survival tomorrow. It is hard to motivate people to make sacrifices to avoid crises that will affect only future generations. The development of some high-impact indicators of sustainability together with models and scenarios in support of integrated assessments should help to make society more responsive. Involvement of users and laypeople in the development of the indicators can also increase buy-in and relevance. Participatory approaches with wide stakeholder involvement are increasingly used to legitimate assessment processes.

Another problem with the policy relevance of assessments and their indicators is that their acceptance often depends on who produces them. People tend to have confidence in those who think like them and share their values, and reject assessments produced by those with opposing views. Businesspeople appreciate the indicators developed by the World Economic Forum (Esty and Cornelius 2002; Esty et al. 2005); conservationists prefer those of the WWF (2004). For some, the UNEP is suspect because it is environmental; for others the World Bank is suspect because it is the World Bank. This reinforces the need to build a more scientific basis for the legitimacy of indicator sets and assessments. Legitimacy and acceptance also depend partly on the track record over time. New indices often are controversial, but if they demonstrate their usefulness and impact over time, they increasingly come to be accepted.

Extent of Applicability

Integrated assessments will be in growing demand as the best way to provide policy guidance on the major directions for future society. They will be needed for a variety of institutions at different levels of governance, from local to global. As the principles for integrated indicators of sustainability are worked out, they should be applicable at a variety of levels and adaptable to different contexts. The techniques for indicating the sustainability of processes and trends, irrespective of the goals of the entity being assessed, should be of general use in many integrated assessment processes, whereas many other indicators will be case-specific.

Gaps in Knowledge and Research Needs

The major challenge is how to integrate indicators of many types across sectors to give an overall evaluation of sustainability. Improved data sets will be an essential prerequisite, but new integrated or linkage indicators are also needed. Just as the GDP measures the flow of money through an economy and thus gives an integrated measure of economic activity, new indicators are needed to measure such features as the flow of natural resources for human use as related to their rate of renewal, the changing balance in various forms of natural capital, the stability of social institutions and networks such as the family, the community and local associations, the vulnerability and resilience of the society, the flow of information, the links between different social entities and environmental processes, and other factors that are critical to sustainability.

Research is needed to explore new approaches to indicators using satellite remote sensing and other observing technologies. These techniques can overcome data gaps by providing uniform planetary coverage and regular time series. For assessments of global sustainability, observing systems should be able to generate indicators of the state of the biosphere, land use trends, the balance between human impacts and natural processes, the status of natural resources, and the extent of poverty in human communities. The Integrated Global Observing Strategy Partnership (www.igospartners.org) and the intergovernmental Group on Earth Observations (earthobservations.org) provide mechanisms to plan and coordinate such efforts.

Another research priority is to find indicators able to capture the less tangible dimensions of human society for integrated assessments. Indicators are needed for the effectiveness of governance, the adequacy of legislation, the flowering of arts and culture, access to science and technology, and other important dimensions of development. The sustainability of a society also depends to a great extent on the strength of its ethics, norms, values, and spirituality (IEF 2002). Although it may be difficult to find direct indicators of these aspects, there may be surrogate measures that can be used to assess their importance and evolution over time (Bahá'í International Community 1998). Until these fundamental but intangible dimensions of society have adequate indicators, they will be invisible for assessment purposes.

Another missing dimension in present sustainability measures is the sustainability of societies themselves from generation to generation. A community or society is sustainable only if it transmits its knowledge, experience, science, culture, wisdom, and values from old people to younger ones before they are lost. Education is a key part of this process, but families, communities, religious and cultural organizations, and the media are also important. With rapid social change, traditional forms of transmission may be disrupted, and significant parts of a society's heritage may be lost before their importance is appreciated. Similarly, new media and information technologies may have both positive and negative impacts on the transmission of knowledge and values. These open a society to the world but often convey values, lifestyles, behavior patterns, and desires for consumption at odds with both the local culture and the needs of sustainability, driving social change in directions with unanticipated consequences. Indicators therefore are needed that capture the effectiveness with which intergenerational information transfer is taking place and the directions in which it is pushing social and cultural evolution.

It may be helpful in identifying indicators of sustainability for society as a whole to undertake a historical analysis of the factors causing the unsustainability and collapse of past civilizations. There may be interactions between social, environmental, political, and cultural factors, or sequences of destabilizing processes, that will stand out better in such retrospective analyses than in any attempt to detect them today. Such analyses could provide a long-term perspective on critical dimensions of the sustainability of civilizations that is lacking in our own society. Indicators could then be developed to follow these dimensions in our own time.

Integrated assessments represent the most difficult challenge for indicators of sustainability because of their need to capture and integrate all aspects of the assessment. Some progress is being made in this direction (Gadrey and Jany-Catrice 2003), but there is still a long way to go before indicators can fully support the integrative aspect of these assessments.

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11

Qualitative System Sustainability Index: A New Type of Sustainability Indicator

Jasper Grosskurth and Jan Rotmans

The Conceptual Challenge

In Chapter 10 Arthur Dahl challenges the scientific community to develop sustainability indicators that "measure the functional system processes that best represent its capacity to continue far into the future." According to Dahl, these indicators should "reflect the whole and not just the parts." Indicators should highlight problems rather than symptoms. We agree with Dahl's perception that existing sustainability indicators do not reflect the whole: "Increasingly comprehensive data sets of indicators covering the state of and trends in economic, social, and environmental factors relevant to sustainability . . . do not capture the interactions between factors and the broader dynamics of the system that are critical to sustainability." In our contribution, we present a concept for an indicator for the sustainability of systems that is designed to address Dahl's challenge.

We define an indicator, following Rotmans and de Vries (1997), as "a characteristic of the status and dynamic behaviour of the system concerned. Or equivalently: an indicator is a one-dimensional systems description, which may consist of a single variable or a set of variables." The characteristic of the system that we are most interested in is its ability to sustain itself in the long run in a desired state or on a desired trajectory. A system with that ability is sustainable.

In order to evaluate the sustainability of a system, we would optimally take into account time, scale, and domain. A measure of sustainability should represent changes in the system that are relevant in the long term of 25 to 50 years. It should reflect developments within the system and trade-offs to systems on other scale levels. It should cover the economic, ecological, and social aspects of sustainability.