PAPER NO. 89

ENVIRONMENTAL ECONOMICS SERIES

Indicators of Environment and Sustainable Development

Theories and Practical Experience

Lisa Segnestam

December 2002

THE WORLD BANK ENVIRONMENT DEPARTMENT

Indicators of Environment and Sustainable Development

Theories and Practical Experience

Lisa Segnestam

December 2002

The International Bank for Reconstruction
and Development/THE WORLD BANK
1818 H Street, N.W.
Washington, D.C. 20433, U.S.A.

Manufactured in the United States of America
First printing December 2002

Contents

TABLES

Acknowledgments

Thanks are due to Kirk Hamilton, John Dixon, and Mohammad Ordoubadi of the World Bank and Mats Segnestam of the Swedish International Development Cooperation Agency (Sida) for useful comments and suggestions on an earlier version of this paper. It should also be noted that neither this paper nor several of the World Bank's indicator initiatives, which the experience referred to in this paper stem from, would have been possible without the generous support of the Governments of Sweden, Norway, and Denmark. This support is greatly appreciated.

Acronyms and Abbreviations

DSR	Driving Force-State-Response
GDP	Gross Domestic Product
GIS	Geographic Information Systems
LPI	Living Planet Index
MDGs	Millennium Development Goals
OECD	Organisation for Economic Co-operation and Development
OECD/DAC	OECD's Development Assistance Committee
PCD	Project Concept Document
PSIR	Pressure-State-Impact-Response
PSR	Pressure-State-Response
UNCSD	United Nations Commission on Sustainable Development
UNEP	United Nations Environment Programme

1 Introduction

Indicators have been used for a long time as a tool with which more information can be obtained about issues as varied as people's health, weather, and economic welfare. Compared to indicators of economic and social aspects, environmental and sustainable development indicators are a relatively new phenomenon. The Rio Conference on Environment and Development in 1992, and other similar environmental milestone activities and happenings, recognized the need for better and more knowledge and information about environmental conditions, trends, and impacts. To achieve this, it was not only necessary to collect new and better data; new thinking and research with regard to indicator frameworks, methodologies, and actual indicators were also needed.

The interest in the World Bank's indicator related work and other organizations' indicator initiatives has been ever increasing over the years. After years of learning, developing and researching indicators, it is time to go back and look at the collected experience and lessons learned (Appendix A presents a list of the various outputs of the indicator work of the Environment Department of the World Bank and Appendix B introduces a selection of other organizations' indicator work). This paper is meant to give a non-exhaustive overview of the more technical aspects of indicator work—definitions, frameworks, and selection criteria – as well as the more practical aspects—data availability, quality and collection, work with different issues and at different analytical levels, tools for presentation and analysis, and ways to disseminate the collected knowledge. The last section of the paper summarizes the most important lessons learned and gives some suggestions for future indicator work.

2 Conceptual Aspects

Definitions

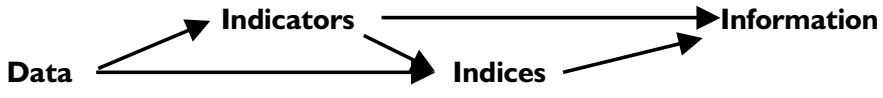
In working with indicators, there are several terms that figure frequently. The most common ones are data, indicator, index and information (Figure 1 shows how data, indicators, indices and information are most commonly linked to each other). These are terms that mean different things in different contexts and for different people. For that reason, this section presents the definitions used in this paper.

Data is the most basic component of indicator work. As such, it is the basis for indicators, indices and information. Most data can not be used to interpret change in the state of the environment, the economy or the social aspects of society. Aspects such as data availability, quality and collection are discussed in a section below.

Indicators, which are derived from data, are commonly the first, most basic, tools for analyzing change in society. Indicators are superior data as an analytical tool for several reasons. Firstly, they can work as a basis for assessment by providing information on conditions and trends of sustainable development. Secondly, as a basis of such assessments, indicators can provide input to policy formulation processes. Thirdly, by presenting several data in one number that commonly is more simple to interpret than complex statistics, they can facilitate communication between different groups, for example between experts and non-experts.

If two or more indicators, alternatively several data, are combined an *index* is created. Indices are commonly used at more aggregated analytical levels such as at the national or regional level[1]. At these levels it may not be easy to analyze the causal links using individual indicators since the relationships between different indicators become more and more complex the more aggregate the analytical level is. However, there are problems with computing indices as well. For example, sustainable development indices are extremely complex to create (see section below on indicator work on different issues for a discussion on this). Indices that cover issues from one and the same sector, or aspect, are thus more common (for example, the Living Planet Index, which "only" covers environmental issues—see Appendix B).

Figure 1. From data to information



Indicators, or indices, are not the end in themselves—they are the means to an end, consisting of improved decision-making. To get a step closer to that end, analyses based on indicators, indices, and, some times, data need to be carried out. These analyses result in *information*, which is the basis for sound decision-making. For the analyses to be complete and accurate, more data, or other indicators than the ones originally monitored, may have to be included. This is quite natural as the purpose of an indicator is for it to indicate a change – not necessarily disclose all aspects behind a change. Not until information is achieved, and the decision-making processes have integrated this information, has the goal of indicator development been reached.

After having introduced the most common terms used in indicator work, it is time to look at the first step of indicator development – frameworks. The following sections look at the other steps in the evolution of an indicator initiative, which are presented in a summarized form in Appendix C.

Frameworks

Indicator frameworks provide the means to structure sets of indicators in a manner that facilitates their interpretation. Indicators are usually needed for many aspects of a problem or issue, and the framework selected ensures that all of those aspects have been taken into account. Frameworks can also aid the understanding of how different issues are interrelated.

In general, different analytical levels require different frameworks. That is to say, depending on the detail of analysis, and the structure and purpose of the monitoring, different frameworks provide the proper support and help. This paper discusses three commonly used frameworks and some variations on a couple of these frameworks:

A. *A project-based framework* (also referred to in the literature as the Input-Output-Outcome-Impact framework), which is used in the monitoring of the effectiveness of projects whose objective it is to improve the state of the environment. Parts of this framework can be used to monitor projects, which risk having an environmental impact without having environmental aspects as their main focus.
B. A framework developed by the Organisation for Economic Co-operation and Development (OECD) for *national, regional and international level analyses.* The first version of this framework is called the Pressure-State-Response (PSR) framework, but has since been developed in three different directions: the first variation replaces the pressure indicator category with a category of driving force indicators (creating a DSR framework), the second variation adds a category of impact indicators, transforming it into a Pressure-State-Impact-Response (PSIR) framework, and, finally, the last version includes all five indicator categories creating a DPSIR framework. The reasons for these developments are presented in the discussions below.
C. A framework based on *environmental (or sustainable development) themes.*

These three different frameworks are now discussed in more detail.

Monitoring at project level

For project-level indicators, the project cycle itself can help to provide a framework. The common steps in the project cycle are:

- Step 1. *Inputs* are provided for the implementation of various project components (for example, money and equipment are provided to install water monitoring stations).
- Step 2. The project is implemented and a number of immediate *outputs* are achieved at the end of the project (for example, water monitoring stations are installed and operating).
- Step 3. The outputs, combined in complex ways, lead to the desired *outcomes* and *impacts* of the project as specified in the project objectives (for example, an increase in access to safe drinking water). The project outputs may, however, also result in adverse environmental outcomes and impacts (so called negative externalities).

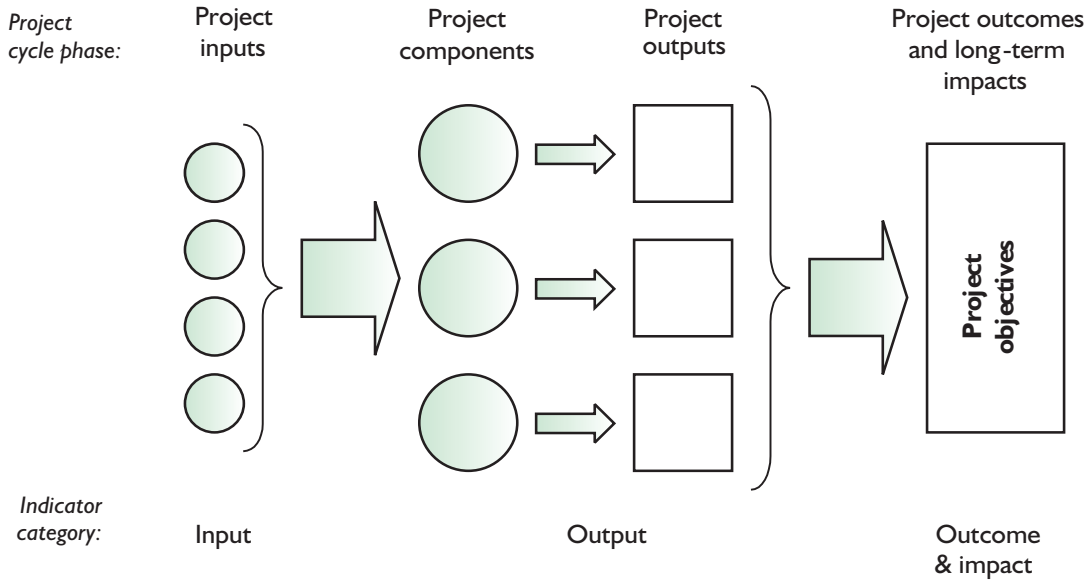
These steps suggest the following classification of indicators:

- *Input indicators*: monitor the project-specific resources provided
- *Output indicators*: measure goods and services provided by the project
- *Outcome indicators*: measure the immediate, or short-term, results of project implementation
- *Impact indicators*: monitor the longer-term or more pervasive results of the project.

The project-based framework is depicted in Figure 2. The figure shows both the various phases of a project and the indicator categories. As can be seen in the figure, indicators are developed for the inputs, the outputs of the components, and the overall project objectives. *Impact indicators* relate to the stated objectives of the project (for example, percent urban and/or rural population with access to safe water), while *output indicators* relate to the components (for example, number of water monitoring stations that were installed). In the same way that the project components are closely linked to the overall objectives of the project, the output and impact indicators should be related.

Note that while the input-output-outcome-impact framework distinguishes between project outcomes and project impacts, the

Figure 2. A project-based framework



distinction between the two categories is not always unambiguous. For this reason, a proposed change is to merge the *outcome* and *impact* indicator categories, referring to the "new" category as 'impact' indicators.

Box 1 presents an example of how the project level framework is used in World Bank operations.

Input indicators are important in tracking the implementation of projects and are therefore key elements of project management. Their design is generally well developed in the community of practitioners. They are also usually more straightforward in their design (a typical input indicator is the amount spent on construction material). Output indicators have also been used to a fairly large extent. In comparison, impact indicators have not figured as frequently in discussions and implementation of projects.

The project-based framework can also be used in part in projects that do not have environmental improvement as the objective, but which may have environmental impacts. The main purpose of including environmental indicators in the monitoring of such projects is to enable an analysis of the project's direct and indirect environmental impacts or outcomes, and indicators of inputs or outputs are therefore not as relevant. It is therefore only the box to the farthest right in Figure 2 that is of relevance when monitoring environmental impacts of non-environmental projects.

Box 1

Using the Input-Output-Outcome-Impact Framework in World Bank Operations

The project-based framework is widely used in World Bank operations. It follows the format used in the guidelines intended to assist World Bank task teams in preparing Project Concept Documents or Project Appraisal Documents[2] for investment operations. This format facilitates the use of the framework, and thus the indicators.

One project that uses the framework is the Maloti Conservation and Development project in Lesotho. While the input indicators proposed for the project are very straightforward (basically monitoring allocated budgets), the output and impact indicators are more advanced. Examples of outputs/objectives and their corresponding indicators include:

Outputs from each component:

Strategic framework for tourism developed and nature-based tourism initiated

Conservation management improved and threats to biodiversity addressed

Global objective:

To conserve globally significant biodiversity in the Maloti mountains within a transfrontier conservation and development area framework

Output indicators:

Increased occupancy and increase gate visitation, tourism traffic increased; length of stay; employment in tourism.

No populations of threatened species in decline; extent of alien plant invasion reduced significantly (no. of ha infested); no. of rock sites mapped and restored; no. of visitors to cultural heritage.

Impact indicators:

Ratification of appropriate international conventions; nomination of sites for international recognition; at least no downgrading according to IUCN categories of threat.

Source: World Bank 1999.

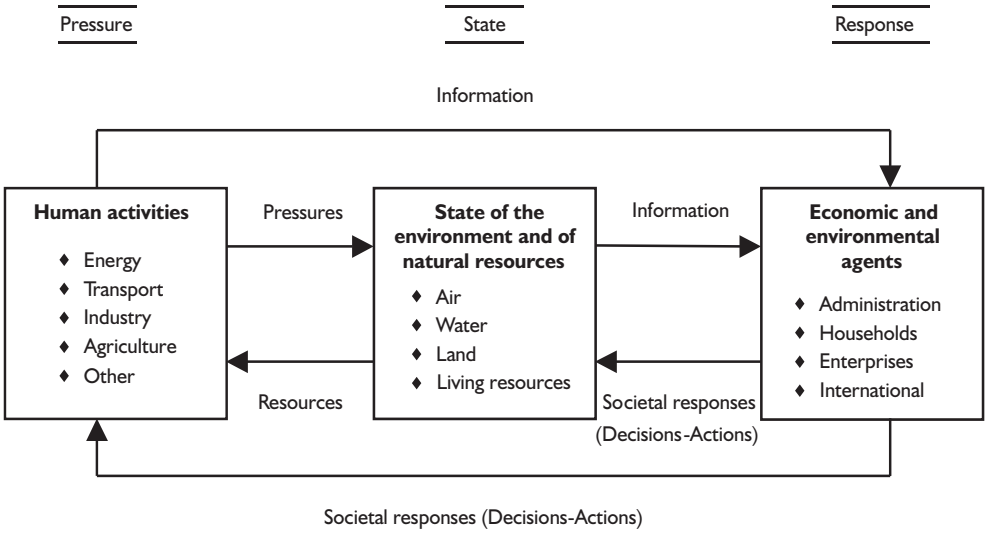
Monitoring at national, regional, and international levels

At a less detailed level, where inputs and outputs are either not relevant or not easily identified, the PSR framework is more useful. Instead of focusing on the different phases of a project, the PSR framework distinguishes between three different angles of environmental issues:

- The *pressure* variable describes human activities or aspects that exert pressures on the environment, that is the underlying causes of a problem. The cause can be an already existing one or a new activity or investment. Examples of potential pressures include income growth, trade patterns and activities, energy use, and population growth.
- The *state* variable usually describes some physical measurable characteristic of the environment that results from the pressure. Examples include indicators that monitor aspects such as water quality, water availability, deforestation, soil erosion, and existence and quality of habitats.
- The *response* variables measure to what degree society is responding to environmental changes and concerns, for example those policies, actions or investments that are introduced to solve the problem. As responses to environmental problems they can affect the state either directly or indirectly. In the latter case they aim to influence the pressures at work. Examples include water-pricing methods, the establishment of resource rents, the use of alternative crops, and reforestation programs.

The PSR framework (as depicted in Figure 3) is based on a concept of causality (OECD, 1994): human activities exert *pressures* on the environment and change its quality and the quantity of natural resources (the "*state*" box). Information about these changes reaches the decision-making instances in society, which respond through environmental, general economic and sectoral policies. These societal responses strive to result in a change of the human behavior, which in turn result in an

Figure 3. The Pressure-State-Response framework



Source: OECD 1994.

improved state of the environment. While the PSR framework has the advantage of highlighting these links, it tends to suggest linear relationships in the human activity-environment interaction. This should not obstruct the view of more complex relationships in ecosystems and in environment-economy interactions. (OECD, 1994) Another critique of the PSR framework is the missing reflection of how a degraded environment affects human welfare, that is, the pressure arrow between the "state" box and the "pressure" box could go in both ways.

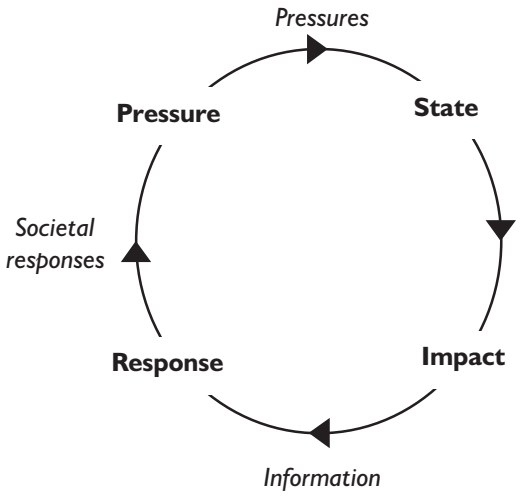
The PSR framework has been developed further by various users. One such development, or change, is the use of *driving force* indicators instead of pressure indicators. The difference between these two indicator categories is their coverage. The advocates of the DSR framework claim that pressure indicators are best used for environmental issues only. Driving force indicators in comparison accommodate more for social, economic, and institutional aspects. In addition, 'driving forces' sounds more positive and can thus be used as explanations to both positive and negative impacts on sustainable development. (Virtual Research and Development Centre, 2001)

A second development of the PSR framework includes the addition of a fourth indicator category. With an increasing use of indicators as a decision-making tool, a need to better separate out the state of the environment, from the changes in that state has arisen. Several organizations have therefore chosen to add an indicator category to the PSR framework—*impact* indicators—to capture the change in the state, thereby creating a PSIR framework (see, for example, Winograd and others (1998)).

In the PSIR framework, the state indicators have the advantage to be able to solely focus on the physical measurable characteristics of the environment, on existing policies (such as water pricing policies), and on management practices used (for example soil management practices – do the farmers have leveled soils? Are the irrigation canals lined?). As such the state indicators explain what factors influence the pressures at work but they also illustrate the current state of the environment. The category of impact indicators is added in order to capture the effects the pressures may have on that state. These indicators would in the PSR framework be included in the category of state indicators, which may at times give less guidance when the step to decision-making, or responses, is taken.

Figure 4 depicts an operational cycle using the PSIR framework. The *pressures* at work affect the *state* of the environment resulting in a number of environmental *impacts*. For example, chemical use in agriculture may have an impact on the state of nearby water resources through excessive water pollution. This is both an impact on the environment per se, but could also risk having human health impacts. To mitigate the pressure, decision-makers need to

Figure 4. Adding another category to the operational cycle — Impact indicators



have information about the underlying causes to the farmers' behavior (and thus the observed pressures and impacts). Therefore, pricing policies for agro-chemicals, possible subsidies, and crop patterns, for example, need to be established with the help of state indicators to create a knowledge on which decisions can be based.

Finally, the decisions made based on the information collected with the help of pressure, state and impact indicators need to be monitored. *Response* indicators can therefore be used to monitor three aspects of the societal responses: i) what policies or investments are introduced to reduce the pressure; ii) whether the mitigating measures proposed are implemented properly; and iii) whether the behavior of the involved actors and the activities exerting the pressures change as expected.

If no changes occur, or if the changes are unexpected, the project design and/or all of the indicators need to be revised. Maybe the assumed causal links are incorrect. The pressure and impact indicators then need to be revised, analyzing other plausible pressures within the area. Maybe there are other policies, management practices, or similar aspects (for example, cultural behavior) that are the explanation to the farmers' behavior, and maybe the responses need to be different to capture those aspects properly. The PSIR framework is flexible and yet complex enough to capture all of these issues. However, the critique of the PSR framework about it simplifying the relationships between the different parts of society is relevant for the PSIR framework as well. Box 2 gives examples of indicators for the water sector developed with the help of the PSIR framework.

The third, and final, development of the PSR framework is the presentation of all five indicator categories (driving force, pressure, state, impact, and response indicators) in one and the same framework, providing an overall mechanism for analyzing environmental problems. In this DPSIR framework, the different indicator categories cover the following aspects of an environmental issue (Virtual Research and Development Centre, 2001) (also see Figure 5):

- *Driving forces*, such as industry and transport produce…
- *Pressures* on the environment, such as polluting emissions, which then degrade the…
- *State* of the environment, which have an…
- *Impact* on human health and eco-systems, causing society to…
- *Respond* with various policy measures, such as regulations, information and taxes, which can be directed at any other part of the system.

Another framework option is to avoid the different angles of an environmental issues and instead focus on the environmental or sustainable development themes themselves. The United Nations Commission on Sustainable Development (UNCSD) initiated the development of indicators for the monitoring of sustainable development in 1995. At the outset, the UNCSD used the PSR framework to organize the indicators selected. However, the framework turned out to be rarely used by testing countries and was therefore abandoned. Instead, the indicators selected were organized according to Major Areas, Themes and Sub-themes (see Table 1). The UNCSD says that "(t)he principal objective of creating a framework formed by Themes and Sub-themes that conceptualize sustainability is to support policy makers in their decision making at a national level." (UNCSD 2000)

Box 2

The Pressure-State-Impact-Response Framework in the Water Sector

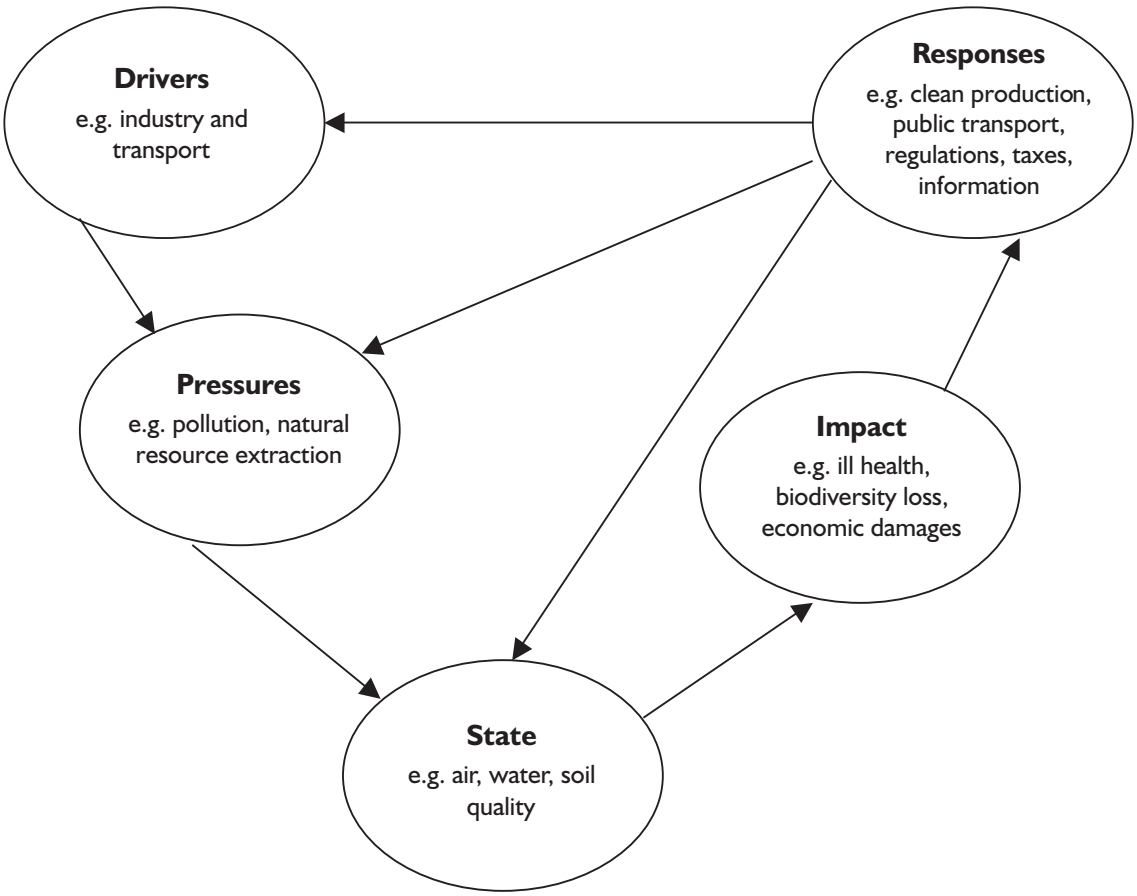
As a sub-initiative to a project on indicators for rural sustainability in Central America, a conceptual case study was developed for the water sector using the PSIR framework. Indicators of issues such as water use, water demand, hydroelectricity generation, water emissions (categorized as pressure variables), water availability and quality (categorized as state variables), population risk, effects on water (categorized as impact variables), water protection and water satisfaction (categorized as response variables) were suggested:

		Detailed information	Aggregated information
Pressure	Indicators of use	Annual extraction per capita (m^3) Annual extraction by sector (%)	Water Vulnerability Index
	Indicators of demand	Total demand (m^3) Use efficiency (%) Recycling potential (%)	
	Indicators of generation	Number of dams (no) Kilowatts per hectare inundated (kW) Hydroelectricity production (mW)	
	Indicators of emissions	N emissions (kg) Other emissions (kg)	
State	Indicators of availability	Reserves (m^3) Rate of recharge ($m^3\ yr^{-1}$) Annual rainfall (mm) Annual extraction as % of total (%)	Water Quality Index
	Indicators of quality	Biological oxygen demand(mg L^{-1}) Chemical oxygen demand (mg L^{-1}) Eutrophication Acidification Colibacilli (m L^{-1})	
Impact	Indicators of availability	People affected by diarrheic diseases (#) Population affected by inundation (#) Toxicity/ Heavy metal concentration	Climatic Risk Index
	Indicators of quality	Population risking inundations (no) Capital risking inundations ($)	
Response	Indicators of effects	Watershed land use Watershed protected area	Safe Water Index
	Indicators of risk	Access to potable water (%) Access to drains (%) Aqueducts (#) Treatment of used waters (%) Water price (US/m3)	

In addition, an index was proposed for the four indicator categories (pressure, state, impact and response). Unfortunately, the data coverage in Central America for the water sector is poor. It was thus not possible to develop a case study using the above indicators and indices. Nevertheless, developing a conceptual model of this sort can help formulate priorities for data collection and indicator development as well as function as a basis for arguments around the importance of well-functioning information systems. As a conceptual framework, it is, of course, also applicable to other countries and regions than Central America.

Source: Winograd and others 2000.

Figure 5. The DPSIR framework



A feature of all of the frameworks discussed in this paper is that they enable the user to determine whether all concerns (whether they are impacts and pressures in general or related to specific themes) are being monitored and addressed. A framework based on sustainable development themes, such as the one used by UNCSD, can additionally facilitate the identification of core issues for sustainability. For this reason, this framework is commonly used among organizations that work on a combination of aspects, such as the ones composing sustainable development. It is also common for initiatives at the international level where causal links between, for example, pressures and impacts can be difficult to determine. There are many more examples of initiatives that prefer to focus on themes rather than on categories of indicators. The Development Assistance Committee of the OECD (OECD/DAC) is one organization that used the same type of framework in its collaborative work on a set of indicators for the Millennium Development Goals for sustainable development (see Box 7 for an introduction to the environmental indicators proposed for the set). Another example is the World Wide Fund for Nature and its Living Planet Report (see Appendix B).

To select a framework is the first step in working with indicators. All frameworks,

Table 1. Major areas, themes, and sub-themes from the UNCSD initiative

Major Areas	*Themes*	*Sub-themes*
Social	Equity	Poverty Gender equality
	Health	Nutrition status Mortality Sanitation Drinking water Healthcare delivery
	Education	Education level Literacy
	Housing	Living conditions
	Security	Crime
	Population	Population change
Environmental	Atmosphere	Climate change Ozone layer depletion Air quality
	Land	Agriculture Forests Desertification Urbanization
	Ocean, seas and coasts	Coastal zone Fisheries
	Fresh-water	Water quantity Water quality
	Biodiversity	Ecosystem Species
Economic	Economic structure	Economic performance Trade Financial status
	Consumption and production patterns	Material consumption Energy use Waste generation and management Transportation
Institutional	Institutional framework	Strategic implementation of sustainable development International cooperation
	Institutional capacity	Information access Communication infrastructure Science and technology Disaster preparedness and response

Source: UNDSD 2001.

however, need to have indicators identified for the respective categories, whether they are project phases, indicator categories, or environmental/sustainable development themes. The next section introduces a number of selection criteria – a methodological aspect that needs to be taken into account when working with indicators.

Selection Criteria

There is no universal set of indicators that is equally applicable in all cases. However, a small set of well-chosen indicators tends to be the most effective approach. There are a number of selection criteria that can be applied when narrowing down the number of indicators. The selection criteria ensure that the indicators are

useful and effective in their provision of information to the decision-makers. The literature on indicators probably has as many selection criteria listed as there are indicators, but the following criteria are appropriate to most indicator selections and are commonly included:

Direct relevance to objectives. The indicator selection must be closely linked to the environmental problems being addressed. It is therefore important that the problem to be addressed in well defined. Vague or overly broad problem formulation, such as "loss in biodiversity" are of little use in selecting indicators (and may well indicate that the issue itself is not very well identified).

Direct relevance to the target group. Different target groups could have different needs and uses for the information provided by the indicators. To carefully consider who the target group consists of is therefore central. For example, an authority responsible for the monitoring of an environmental aspect in a country is likely to need more detailed information than the general public could even digest. The authority could therefore need a larger set of indicators, while the general public would be satisfied (and probably the indicator initiative would be more successful) with a small set of "headline" indicators (that is, indicators that signal something which makes people react as we do when reading the headlines in a newspaper).

Clarity in design. It is important that the selected indicators are defined clearly in order to avoid confusion in their development or interpretation. Clarity can mean different things for different groups of people – whether the indicator needs to be scientifically very solid, or rather be very communicable is therefore something to consider. Who the audience of the indicators is central for this selection criteria.

Realistic collection or development costs. Indicators must be practical and realistic, and their cost of collection and development therefore need to be considered. This may lead to trade-offs between the information content of various indicators and the cost of collecting them. What is important to remember is the corresponding *benefit* of new indicators—an indicator should be *relatively* inexpensive to develop, that is, the benefits should exceed the costs.

Even though it may sound paradoxical, the development of two sets of indicators can help to lower the costs through a division between indicators that are collected as a first priority, and indicators that can be considered as second priority. This can be done in a couple of different ways, which have different purposes of the monitoring (for a summary of these two ways, see Table 2). One way is to develop a *core set* of indicators consisting of a number of indicators that monitor issues relevant at a more aggregated level. The core set of indicators can then be supplemented by another set of indicators that either look at issues that are not common for the whole monitored area, or provide a more detailed picture of the selected issues once the core indicators have established that changes are occurring. This approach has been used at an international and regional level, where the main objective is to be able to compare the values of the indicators among the countries. A set of core indicators, monitored by all the countries involved, has therefore been part of that objective. However, the individual countries have also been encouraged to monitor other issues that may be of importance for them, and not necessarily for all the countries

Table 2. Keeping development and collection costs down

First priority: To be able to compare areas/countries/regions	*First priority: To be able to give early warning to decision makers*
Core set	*Alarm indicators*
Indicators to be monitored by everybody involved in the monitoring initiative to enable comparison between monitored areas/countries/regions.	Indicators to be constantly monitored in order to give timely warning about adverse changes threatening to exceed set thresholds.
For example, access to safe drinking water	For example, electric conductivity of water
Supplemental/complementary set	*Diagnostic indicators*
Indicators to be monitored by a smaller group for whom the supplemental indicators are relevant, AND/OR to show more detail on the issues highlighted by the core set of indicators.	Indicators to be monitored to enable an in-depth analysis of the issues highlighted by the alarm indicators.
For example, desertification (not relevant for all countries in the world), pollution sources (to establish causes behind the lack of access to clean water).	For example, more monitoring points of electric conductivity of water.

involved, with the help of a supplemental set of indicators. One example of this is the OECD/DAC's initiative of indicators for the Millennium Development Goals (see Box 7). A set of indicators was developed to be monitored by as many countries as possible in the world. The core set of indicators therefore had to cover issues that were common for all those countries. However, several countries highlighted the need for indicators to monitor other, nationally relevant, issues, such as desertification. Those countries were therefore encouraged to develop a supplemental set including those indicators that were country specific and not necessarily relevant to all countries involved. This approach could be used at all analytical levels.

Another approach is to develop one set of *alarm indicators*, and one set of *diagnostic indicators*. In this approach, the issues are relevant and present throughout the area and process, and the first priority of the monitoring activity is to give early enough warning about adverse environmental effects in order for decision-makers to react. There is therefore a difference in the purpose of the alarm and diagnostic indicators. The alarm indicators are a small set of indicators whose development and monitoring are low cost, permitting a frequent monitoring. They are also specifically chosen to give an early warning about changes and signal change in time for policy-makers to react.

Diagnostic indicators, in comparison, are a second set of indicators that is activated if the value of the alarm indicators crosses a predetermined threshold and that enables a more in-depth analysis (or diagnosis) of the causes of the alarm. The diagnostic indicators give more detailed information about the issues at hand and sometime cover a larger area than the alarm indicators. As a result they are generally more costly. In addition, they generally do not provide the monitoring agency with enough lead-time for a timely reaction to the problem. All of these characteristics make them appropriate as diagnostic indicators rather than as alarm indicators.

This approach was used in a policy relevant monitoring system for watershed management

in Costa Rica. Box 3 discusses alarm and diagnostic indicators in more detail, as well as examples from the Costa Rican project.

High quality and reliability. Indicators, and the information they provide, are only as good as the data from which they are derived. For most monitoring systems there is a discrepancy between what is realistic or practical for the moment, and what would be most useful or "ideal", for the system to cover. If the "ideal" indicator to measure a problem is based on unreliable data, it is common to depart from the "ideal" indicator and use proxies instead. However, it is always useful to consider the alternative to the proxies—the "ideal" indicators—as the development of those may not be as impossible or costly as one might imagine, especially if the corresponding benefits are correctly estimated.

Appropriate spatial and temporal scale. Careful thought should be given to the appropriate spatial and temporal scale of indicators. Since the environmental impact of activities seldom coincides with administrative boundaries, indicators often need to be measured on different scales. There might also be lags in time before project effects are felt.

Apart from these criteria, which are applicable and relevant for indicator selection at all analytical levels, there are examples of other

Box 3

Policy Relevant Indicators for Watershed Management

The World Bank has, together with the International Food Policy Research Institute, ProDesarrollo Internacional and the government of Costa Rica, developed a policy relevant monitoring system for a watershed in western Costa Rica. The monitoring system consists of three components: a model that provides a means of identifying the causes of an emerging problem and evaluates alternative options for fixing it, an institutional framework which discusses how the involved institutions affect and are affected by the proposed monitoring system, and, finally, an indicator component.

The main part of the indicator component is developed in such a way that it is possible to keep costs down and yet follow the developments within the watershed. This is made feasible with the development of alarm and diagnostic indicators.

In the policy relevant monitoring system developed for the watershed in Costa Rica, the diagnostic indicators are also used in an economic model, which uses the indicators as a base for the evaluation and comparison of potential responses. The results of the monitoring of the alarm and diagnostic indicators can be used in other, more "direct" ways as well as long as the indicators are fairly clear in what they signal. The possibilities of acting directly on the monitoring results depend on the capacities of the monitoring institutions and the monitoring system those institutions have selected.

To demonstrate the interaction between the alarm and diagnostic indicators, the issue of salinity in the soils in the downstream areas of the Costa Rican watershed can be used. There are several potential culprits to increased soil salinity levels in the downstream areas; basically every farmer in the area could be the cause of such an observed change. Electrical conductivity of the water is a fairly straightforward pressure indicator that gives a much quicker warning than the relevant impact indicator – agricultural yields – would. Furthermore, agricultural yield is more ambiguous as an indicator since changes in yield can depend on many other things than whether the soils are saline or not. As an alarm indicator it is therefore proposed that one monitors the electrical conductivity at the points in the drainage canals where an existing monitoring system is already measuring. However, to be able to direct any interventions correctly when the alarm indicator reaches its threshold, the individual farmers experiencing the salinity problem need to be identified. A diagnostic indicator, similar to the alarm indicator is therefore proposed to be monitored at each of the farms, at different points for a complete coverage of areas potentially affected by salinization.

criteria whose appropriateness depends on the level of the indicator initiative:

- *National* or *regional* level: The indicators are preferably **national in scope** or **relevant to an issue of national concern**. If the developer or user wishes to create an index, it is also an advantage if the indicator is **quantifiable**.
- *International* level: The indicators are preferably calculated using **available data** considering the cost of developing new indicators; especially for hundred countries or more. The indicators selected should also be **available in all countries** since inter-country comparisons are commonly a purpose with such initiatives. For such comparisons to be possible without disagreement, **international consensus** is preferable to the largest extent possible. (UNDSD 2000.)

Alternatively the selection criteria can depend on the issue to be analyzed. In the literature, such selection criteria are specifically discussed in relation to sustainable development analyses. The following specific selection criteria for sustainable development are taken from "Sustainable Development in the United States. An Experimental Set of Indicators" (US Interagency Working Group on Sustainable Development Indicators 1998):

- The indicator should *reflect changes in important endowments* (for example, public infrastructure, air or water quality, natural resource stocks and governmental institutions).
- The indicator should *reflect an issue that could have significant costs or benefits for current or future generations* (for example, technological advances, political stability, loss of biodiversity, status of children and desertification).
- The indicator should *reflect an issue that can only be addressed over a period of years, decades or centuries* (for example, global climate change).
- The indicator should *reflect an issue that involves thresholds beyond which small changes could potentially lead to irreversible effects* (for example, endangered species becoming extinct).

After having introduced the most commonly used frameworks, and a number of selection criteria that are useful in the establishment of indicator sets, it is now time to look at the more practical aspects that play a role in the work with indicators. Many times, practical aspects can be a great challenge – sometimes to the extent that it seems impossible to achieve something useful due to lack of data, low quality of existing data, difficulties in developing useful indicators for the analytical level in focus, or even due to difficulties in presenting and disseminating the results in an effective manner. The following sections present and discuss various experience gained in indicator work of the World Bank and other organizations. For some areas, where the experience is quite extensive, advice is given on how to overcome these obstacles, but in many cases discussions are all that is possible since a complete answer is yet to be found.

3 Practical Aspects

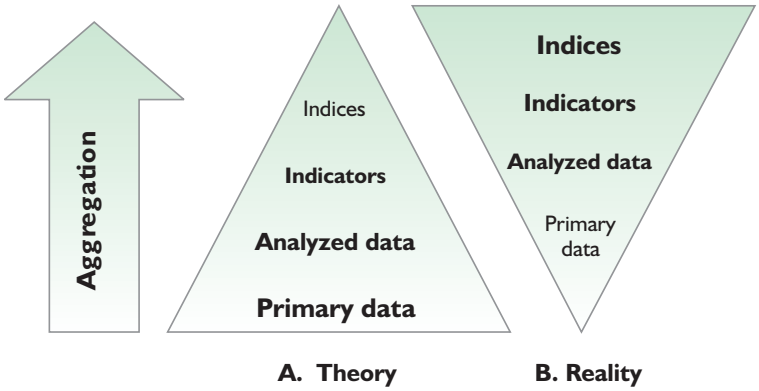
Data Availability and Quality

The lack of data in general, and reliable data specifically, is a common problem in the indicator world. This is true for most indicator initiatives at most analytical levels. Due to their relative infancy, environmental data are difficult to come by compared to data for economic and social indicators. The *theory* behind the development of indicators and indices looks like Figure 6A, with a broad base of good quality primary data on which the indicators and indices can rest on. To show a simplified picture of *reality*, this information pyramid is commonly turned upside down (Figure 6B) with many indices developed using the same, limited data sets that currently exist. As is discussed below, this should and does not necessarily hinder and discourage the development of indicators today, but the figure clearly illustrates the need for new and improved environmental data. While the problem of data availability and quality can be relatively easily solved at the project level through the inclusion of a data collection component, it is commonly a bigger problem at the national or regional level, considering the costs involved in collecting new data for a whole country or region.

What are the different issues that work as a constraint to the development of new and useful environmental data? In its Global Environment Outlook 2000 report (UNEP 1999), UNEP (the United Nations Environment Programme) discusses two categories of constraints—institutional and technical:

- The *institutional* constraints are divided into four categories: i) general institutional constraints—limitations in resources, personnel and equipment; ii) data reporting

Figure 6. The information pyramid



units—difficulties with the aggregation and comparison of data sets; iii) data management—lack of central compiling systems; and iv) relevance—lack of relevance of certain issues for some countries result in incomplete global data sets.

- In addition, the report includes six categories of *technical* constraints: i) definition differences—vague definitions, and differences in definitions between countries, risk resulting in misinterpretations; ii) coverage of monitoring networks—the lack of monitoring networks results in gaps in data time series; iii) different reporting periods—difficult to compare countries' collected time series; iv) gap filling—using various estimates, instead of real data, can lead to misinterpretation; v) conceptual and technical difficulties of measurement—certain aspects of sustainable development are difficult to monitor over large geographic areas or to determine the cause and effect relationship; and vi) differences in measurement method—data that are incompatible risk ending up in the same aggregated data set without detailed analysis of data collection and measurement methods.

In addition to these two categories of constraints, a third category could be relevant to introduce—*political* constraints. Especially environmental issues have not always been high on the list of priorities for governments around the world. One reason for this is quite likely the short-term perspective that most politicians have due to the shortness of political terms. The political willingness to invest in the environment, or even in sustainable development, which both typically demand long-term investments, has thus been low. To the people who work with these issues, there is agreement on the need for dissemination of information about the importance of these aspects, not only for the environment itself, but also for the welfare of the people in the countries. Without that knowledge, the public opinion will not change, thus the demand for these aspects in political decision-making will not change, and, since the politicians generally listen to the public opinion, the political willingness will continue to be low. These constraints of low priority and political willingness have consequently led to small, or non-existing, budgets, since there have been so many other things to spend money on. The result being that the data collected have been economic, or in some cases social, but to a lesser extent environmental.

Many of these constraints require resources, time, equipment and personnel to deal with. Considering reality in many countries, the improvement of data availability and quality is therefore a long process. In the meantime, environmental and sustainable development aspects need to be monitored so that they are not ignored in decision-making processes. A solution to this problem is the use of already available data.

Available data should be used to the greatest extent possible and with creativity in order to reduce the cost for involved parties. It is not uncommon that data on a national level are demanded for a regional or international initiative in which it is difficult to find resources to develop new data. Imagine, for example, an international initiative, which identifies a new indicator to be developed by as many countries in the world as possible. To collect completely new data and develop a new indicator for a hundred countries or more would not only be

extremely costly, it would also be very difficult to arrange in a practical way. To use proxies in the form of already available data to begin with could therefore be the only feasible solution (except from the alternative of not developing an indicator set at all, which, most likely, would be a worse alternative from a sustainable development perspective). However, the common and widespread problem of non-existing or low-quality environmental data should not be forgotten, and new initiatives on data collection should be considered as well.

At the project level, the issue of data availability and quality looks a bit different. To include a data collection component in an indicator initiative for a well-defined smaller area does not have to be expensive, nor impractical. There are, however, several aspects to consider in the development of a data collection component.

Data Collection

Collection of data can be arranged in many different ways. Whether the indicator initiative is at the project or a more aggregate level will matter for the methods used. At the project level, the implementing agency may be the best data collector – they are already in place, and the data for the particular project are not likely to exist already. At the international level, there are two levels of data collection – first the data need to be collected within the countries, second an international organization needs to collect the data from the individual countries. This is also the common method for indicator initiatives at the regional level, unless a regional organization collects the data from the national organizations. At the national level, the most common solution is for a national organization or ministry to be responsible for the collection of data for their specific field of interest.

For an indicator initiative that has as its objective to study an area within a country, for example a watershed, the methods and possible implementers look a bit different. Existing literature may include data that can be compiled through a desk study, external companies or institutions specializing in the issues can be contracted, organizations representing the stakeholders' interests can be involved using their vested interests as an incentive, schoolchildren can participate as part of their education, or the local population – for example farmers, residents, and researchers – can be encouraged to take an active role in the changes of their social, environmental, and economic surroundings by contributing to the data collection.

If an external company or institution is contracted, transports, meals and housing costs for the professionals need to be covered. This implicates that the monitoring will be more expensive than if the local population or organizations are trained for the task of collecting the data. This is especially true if the monitoring system becomes more permanent, resulting in high contracting costs when accumulating over time. Another advantage of involving local stakeholders is the enhanced support and sustainability of the project that usually follow.

Several issues are relevant for the data collection phase—independent of the analytical level. Aspects such as credibility, cost efficiency, and incentives are important, and determine not only the quality of the monitoring system, but also its sustainability and the possibilities to integrate it into the decision-making process.

Credibility

In order for the indicators to play their role in full, the data collected have to be credible. This

implies that the data collectors need to be so. If the results are not credible, both explicitly (results of poor quality) and implicitly (results are not credible due to the data collector's vested interests), the indicators may never be used.

Hence there are two aspects to credibility that come into play: *trustworthiness* and *capacity*. It is important that although a data collector may have an interest in the monitoring results showing a certain "truth", other groups, that will use the indicators, can trust the results that come out of the monitoring. Trust is therefore important, but so is capacity. The monitoring results may very well be developed by a trustworthy organization, or company, but if they do not have the proper capacity to develop and analyze the indicators, the results may show wrong trends.

A solution can be to create "monitoring teams" consisting of one agency that collects the data, and one that controls the quality of the results of the data collection. In that way, it is possible to achieve cost-efficiency and credibility even in the cases where one single agency does not possess both characteristics. For example, if a monitoring system is set up in a watershed where different actors, including a hydropower company and farmers, are sharing the resource of water, a "monitoring team" could consist of representatives from both of these groups. The hydropower company would most likely be collecting data on water supply, while the farmers could work as quality controllers, ensuring that the data submitted by the hydropower company are trustworthy.

Cost effectiveness

The discussion on credibility also needs to take cost-effectiveness into account. Some of the indicators proposed may already be collected by various organizations, or they may be about to be included in various programs. As long as the developers of those indicators are reliable and trusted by the other stakeholders, there is no reason to start developing the same indicators within a different organization. On the contrary, the more costs can be cut by taking advantage of already established monitoring systems or programs, the better it is.

Incentives

The various costs and benefits need to be studied properly when deciding which institution to put in charge of the monitoring. This last aspect also raises the question about how to get the institution to agree to spend the money on monitoring – an issue of incentives.

Most monitoring or data collection implies various costs for the collector. If the monitoring agency is to agree to bear these costs, the proper incentives need to be established. Such incentives can be created in many ways, for example, through regulations, laws, fines, compensations, and economic benefits – all depending on the level of the indicator initiative. Incentives for data collection at the national level are probably best created through regulatory requirements, laws, political or statistical mandates, or through dissemination of information to the public and others about plausible benefits from a changed behavior. At the international and regional levels the best incentive is commonly mandates, for example the mandate of a non-governmental organization to disseminate information about deforestation in the world. The incentives at the project level can be created through regulations (the organization paying for the project may demand that the project be monitored) and

through economic benefits (it can be costly for the project if it is heading in the wrong direction).

Practical Considerations for Work with Different Issues

Apart from the more technical and conceptual aspects discussed so far in this paper, there are several considerations that need to be taken into account when working practically with indicators. This section discusses the most influential ones of the considerations that are relevant in the work with different issues, such as pollution, natural resource management and various cross-cutting issues.

Geographic scale

In working with indicators of natural resource management and pollution, the geographic and the time scale of the indicator play a significant role. The *geographic scale* is partly an issue of globally significant indicators versus locally significant indicators. For example, the extinction of a species in a region within a country may be of serious concern for that region, even if the species is not near extinction globally. At a global level, there may even be completely different species that matter.

The role of indicators in decision-making processes that concern natural resource management and pollution aspects is also potentially linked to the geographic scale. Indicators of pollution and natural resource management do not always coincide with politically defined areas, to which decision-making is commonly delimited. A watershed is typically such an area, where it is common that the area for which the indicators are relevant is at a much larger scale than the areas for which decisions are taken. In the practical work with indicators, collaboration between governments, sub-national organizations or local groups is therefore fundamental. If the indicators are developed according to the political boundaries, both the interpretation of the indicators and the indicators themselves risk being far from perfect or irrelevant and, thus, result in either incorrect measures or measures that fail to appear.

Time scale

The *time scale* of an indicator also affects the usefulness and interpretation of indicators. The issue of time becomes important in the design of mitigating measures and to enable prevention rather than reaction to a problem. If the indicator is meant to give enough warning about, for example, extinction, the number of extinct species is not appropriate since their role in *preventing* extinction is limited to say the least. Several indicators do, furthermore, not indicate change until some time has passed, and may therefore be less appropriate in a decision- and policy-making environment. In monitoring issues with such characteristics, consideration needs to be taken in the early stages of the monitoring initiative. If taken into account early enough, it may be possible to implement actions for the reduction of long-term impacts before those impacts are noticeable. Initiatives that value the long-term losses may also be necessary to begin at an early stage to be able to motivate further investments in mitigating measures.

Different considerations for different issues

Pollution indicators

Apart from these common considerations in the practical work with indicators, there are a few that are specific for pollution and natural

resource management monitoring respectively. For example, while several pollution issues may be more difficult to interpret than some natural resource issues due to their commonly global characteristic, more and more practitioners agree on the indicators to use in their monitoring. The World Health Organization has developed global standards of water quality, air quality indicators have been used in many cities around the world, and their monitoring is fairly easily motivated due to their link to human health. Impacts from many pollutants also commonly take longer before they are detectable and last for a long time—indicators of pollution therefore have to consider the time scale issue discussed above.

Natural resource management indicators

Many indicators of natural resource management, on the other hand, show an impact directly (even though the importance of that impact may be of the long-term nature). Deforestation is apparent the same instance it happens, so is land use change. There are of course other indicators that may not show a clear trend immediately – indicators of water use may belong to that category since it may be

Box 4

Why the Monitoring of Biodiversity and the Like Is Complicated

Biodiversity is here used as an example of the difficulties in defining and developing indicators for some issues such as biodiversity and several cross-cutting issues including sustainable development. The monitoring of biodiversity has traditionally been difficult due to several factors. These factors can be divided into political, conceptual, practical (technical), and institutional factors:

Political factors. Factors that affect the development of biodiversity indicators are often political. *Political willingness* to prioritize an issue such as biodiversity, and to spend money on the monitoring of it, is commonly low since the benefits to the general population sometimes can be difficult to identify. This in turn is often a result of *ignorance* – the economic benefits of conserving biodiversity, or the economic losses of destroying biodiversity, may not be analyzed enough. The ignorance can also be a result of a traditionally greater focus on biodiversity's nonutilitarian values as opposed to its utilitarian values, which may result in a lower priority given to biodiversity conservation.

Conceptual factors. The monitoring of biodiversity is extremely complex as a result of various aspects. First, the *diversity within the concept* of biodiversity demands a flexible approach to the selection of indicators. Different aspects such as genetic diversity, species diversity, diversity in untouched areas, and diversity in agricultural areas all require different indicators. Second, the *ambiguity* associated with the term "diversity" itself creates confusion in how to monitor and measure it. Third, the *multidimensional roles* mentioned above contribute to the complexity. This intricacy clearly creates problems when one tries to express it in a few selected parameters.

Practical (technical) factors. The general problem of a *lack of data* plays a significant role for the few identified biodiversity indicators that are currently commonly used. Difficulties in being exhaustive in the measuring of biodiversity indicators are noticeable. In addition, practical *measuring problems* result in a lower reliability in the data that do exist. For example, "number of species" is a commonly proposed and used indicator of biodiversity. However, with the current knowledge gaps in, for example, how many species actually exist, such an indicator does not necessarily reflect reality.

Institutional factors. Capacity to develop and, perhaps even more important, to interpret and analyze the developed indicators is commonly lacking in many countries. The capacity needed is both of the human and of the technical kind. Hammond et al. (1995) state, for example, that "national measures of biodiversity of use to policymakers may be impossible to compile unless they are based on spatially referenced data – essentially digital maps." While the technology to achieve this is becoming more and more developed, it is still far from available to all involved parties.

difficult to establish a threshold for sustainable use of fresh water resources. Effective management, and thus quality, is therefore a central aspect in the monitoring of natural resources. This is easily missed when only monitoring number of hectares of deforestation or people trained in environmental management. Some natural resources are furthermore difficult to monitor due to their characteristics. For example, it is difficult to estimate marine fish stocks and the richness of a country's biodiversity due to the vast areas utilized by the resource. Unlimited monitoring areas are not the only reason why issues such as biodiversity are complicated to monitor. Political, conceptual, practical and institutional factors all contribute to the complexity of some issues (see Box 4).

Institutional indicators

For the development of institutional indicators, the considerations look slightly different. In some cases, indicators simply note the presence or absence of institutions, laws, regulations or strategies. However, these so-called commitment indicators demonstrate a number of problems. First, they do not reveal whether the management, enforcement or implementation is effective, that is, the quality is not monitored. Second, they are commonly fairly limited in their coverage. One aspect that is often forgotten in the monitoring of institutional development is public attitudes—an aspect that may not only be the reason for decision-makers to consider the environment from the beginning, but is also vital for the success of change. (Segnestam 1999.)

Cross-Cutting Indicators

For the more cross-cutting issues, complexity is the most central practical consideration. How can one capture several different aspects in one, or a few, indicators? Causal links are here fundamental. Without established causal links between, for example, poverty and environment, relevant indicators are not possible to identify. This may sound obvious and something that is true for all indicator development. However, most cross-cutting issues with regard to the environment have only been researched to a minor extent and many causal links have thus not been established yet. On the other hand, the recommendation to use existing data and indicators creatively is applicable here as well. Many indicator initiatives around the world have included indicators that can be interpreted in a "cross-cutting setting". One such example is the commonly used 'access to safe drinking water', which mirrors some of the links between poverty and environment, and health and environment. Another is the index of environmental vulnerability (which shows risk of inundation and land slides) developed within the CIAT-World Bank-UNEP collaborative project on rural sustainability indicators for Central America – an indicator that furthermore mirrors management issues (Box 5).

Interpretation

In general, complexity creates problems for any indicator developer. This has become especially obvious with the last years focus on sustainable development. While the experts consider all the critical factors as vital to follow, politicians keep asking for a few indicators, or "the one" to base decisions on. This "conflict of opinions" circles around the issue of *interpretation*. The use of indicators that consist of several indicators, or data combined in a way to give a more complete picture of the monitored aspect (so called composite indicators), is common in the monitoring of sustainable development. The

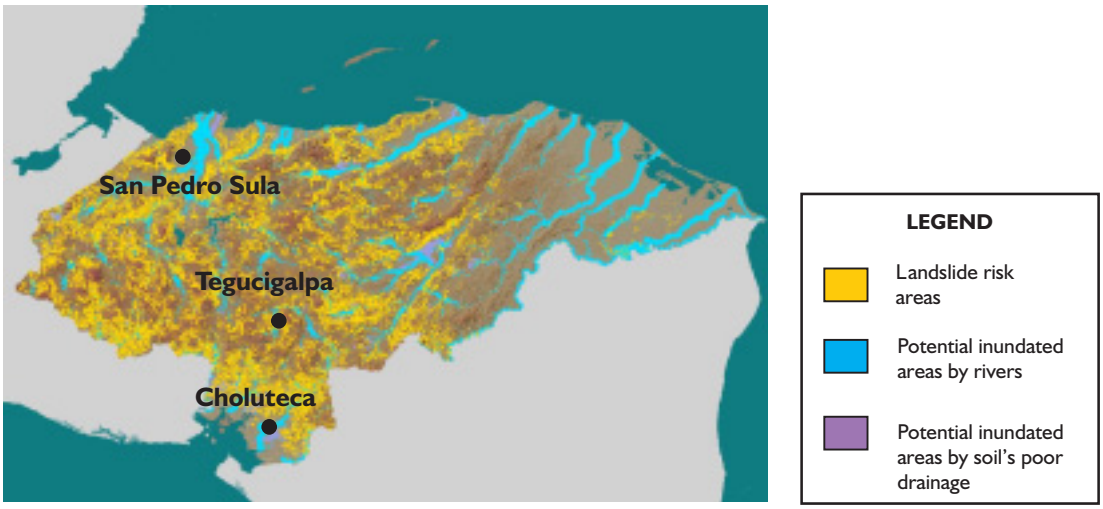
Box 5

An Index of Environmental Vulnerability

Figure 7 illustrates an environmental vulnerability index calculated for Honduras. This index takes such issues into account as the biophysical characteristics of the environment, and shows the risk of landslides and inundation (flooding). It is computed through the creation of intermediary maps of flood and landslide risk using data on forests, rivers, topography, slopes, soil permeability, and vegetation. Only the risk of landslides and flooding are highlighted in this index due to the impacts suffered in Honduras in the wake of Hurricane Mitch. An environmental vulnerability index, could, however, highlight other aspects as well depending on what a country or region is vulnerable to.

The map clearly shows an alarming picture with over 60 percent of the territory being under some type of risk of flooding or landslide, in particular the more populated and agricultural areas, for example the axis San Pedro Sula-Tegucigalpa-Choluteca. This first tells us that environmental vulnerability, and the risk of being affected by floods or landslides, need to be dealt with in one way or the other. We furthermore know the areas in which interventions need to implemented, and we have some ideas of what needs to be done (e.g. experience tells us that planting trees can help prevent landslides from happening). If the information provided in Figure 7 is combined with other types of data, such as data on location of the population, poverty levels, and the location of infrastructure, a more integrated and complete picture of a country's vulnerability can be achieved, which can be used as the basis for decision-making and planning. For more information about this type of combined vulnerability index, see Segnestam and others (2000).

Figure 7. Environmental vulnerability index



Source: CIAT 2000.

interpretation is then complicated by the many different trends that can occur *within* the indicator itself—is it a positive or negative change if the value of one part goes up at the same time as the value of another part goes down? The relative weights "internally" need to be established, an issue that is often difficult to agree on. Another problem with large sets of indicators or indices is that they commonly reflect the specific expertise and research interest of the organization that "invents" the set or index. Hence, they are often biased towards one aspect, for example environmental. However, there are several other aspects to consider in solving this "conflict" between sets of indicators or one single index, whether it is of

sustainable development or other cross-cutting issues. Box 6 presents some of the most commonly discussed. The most important features (apart from the more general features discussed in the section on frameworks above) of frameworks for the monitoring of sustainable

Box 6

Indicators of Sustainable Development — Sets of Indicators or "One Big Index?"

Many concerned with sustainable development would like to see a single indicator to compete with the enormous political power of the Gross Domestic Product (GDP). In addition, it is becoming more and more common for decision-makers to ask for a single, powerful number that is easy to understand and use in decision-making. But many are skeptical that a single number could assess something as complex as sustainable development, especially if one considers all the criticism that has been raised against GDP. The skeptics are instead promoting sets of indicators that include numbers on the most important aspects of society's well-being. The tables below present some of the pros and cons with a single indicator and indicator sets respectively.

Indices of sustainable development

Benefits	*Problems*
♦ The aggregation of indicators makes it possible to obtain clear messages, gain an overview of sustainable development, and show where performance is especially weak or strong ♦ An aggregated indicator of sustainable development can compete with the GDP indicator in the communication to the general public about material well-being ♦ Aggregated indicators explores the relationship among the variables, which lies at the heart of the linkages intrinsic to sustainable development	♦ An aggregated number is more difficult to quality assess since the aggregation hides the individual parts of the indicator ♦ The actual aggregation may become a bit ambiguous when items, whose units differ, are added together (for example, life expectancy, educational attainment and adjusted income as is done in the Human Development Index) ♦ The aggregation is, in general, difficult to achieve in a clear and unambiguous manner since it demands weighting of items that are difficult to value ♦ An aggregated number may be good for comparisons between countries, or regions, but does not necessarily have a functional value as a policy tool

Indicator sets of sustainable development

Benefits	*Problems*
♦ Quality assurance of the individual indicators is made easier ♦ A set with several indicators provide countries with more flexibility with regard to which indicators to include (according to variations in conditions, activities and priorities) ♦ A set with several indicators can be based on indicators that are conceptually accepted and familiar to developers and the public	♦ The linkages between the economic, social, and environmental trends in society as well as between and among systems are not always illustrated properly for the sets to be measuring sustainable development ♦ It is not uncommon that sets of sustainable development indicators include multiple indicators for essentially the same issue while hardly (or not) including indicators of other important issues ♦ Their assessment is made difficult by the diversity of issues that different indicators measure, and the different directions in which the indicators move

development is probably i) that it assesses trade-offs between different dimensions of sustainable development, and ii) that it helps set priorities across different policy areas (OECD, 2000a). These features are important whether the monitoring is carried out with the help of a set of indicators or an index.

Practical Considerations for Work on Different Analytical Levels

As the above discussions on frameworks and selection criteria already have made clear, the analytical level can be of importance for the design and development of an indicator. In addition, the analytical level can play a role in the interpretation of the monitoring results. Just as for the monitoring of various issues, there are a few considerations that need to be taken when working practically with indicators at different analytical levels – considerations that differ according to the level that one works with.

These differences can be demonstrated using implementation as an example. While all analytical levels demand an identification of the institution that is responsible to implement any suggested mitigating measures or other actions that may come out of the monitoring results, the process for the identification may differ depending on the level of analysis. For example, at the local level, the actors may be easily identified, and the responsibilities among them clearly stated. However, at the international level, the identification of such responsibilities may be extremely sensitive since the willingness to carry out change must come from within the individual countries. No international monitoring body can thus declare the various countries' respective responsibilities.

International level

The *international level* is in general more "political" than the other levels. This expresses itself through considerations such as the need for consensus on the importance of issues to monitor and the selected indicators, the importance of global institutions to take the lead and structure the development of an indicator set or an index, and the sensitivity among countries in international comparisons. The latter is commonly an objective of international initiatives. Two other common features of international initiatives are the inclusion of global indicators (for example, emission of greenhouse gases and ozone depletion), and that the indicators are of the type that monitor progress or degeneration of various environmental aspects (thus they focus on environmental themes as opposed to aspects (pressure, state, impact or response) of environmental problems). For a brief introduction to an international initiative and the challenges it met, see Box 7.

Regional level

The *regional level* is quite similar to the international level since it still involves a number of different countries. Consensus on the various issues to monitor and the indicators selected is therefore still of importance. The process of determining consensus can form the basis for conflict resolution (both in relation to issues and indicators, and to "losers and winners" of possible changes in current practices). In addition, the monitoring often aims at establishing trends of progress or degeneration. However, there are other possibilities as well. At the regional level, indicators can also be used to ascertain causal links for issues that are relatively well analyzed. For such issues, and also for areas which are well defined, the objective can be to monitor

Box 7

International Collaboration on Sustainable Development Indicators

Developing sustainable development indicators at an international level can not be categorized as an easy task. In 1996, the Development Assistance Committee of the Organization for Economic Co-operation and Development initiated such an effort, the indicators for the then called International Development Goals (IDGs) initiative, inviting the United Nations, the World Bank and the International Monetary Fund to become partners. Over the four years that followed, five working groups discussed indicators for issues such as poverty, education, gender, infant and child mortality, maternal health, HIV/AIDS, malaria and other diseases, environment, and global partnership.

At a later stage, the name of the targets changed from the IDGs to the MDGs (the Millennium Development Goals). Each goal has a number of targets identified, which are more specific in their character. The targets for environmental sustainability and regeneration are: i) Integrate the principles of sustainable development into country policies and programmes and reverse the losses of environmental resources; ii) halve, by 2015, the proportion of people without sustainable access to safe drinking water; and iii) have achieved, by 2020, a significant improvement in the lives of at least 100 million slum dwellers. The working group on environmental indicators agreed on nine indicators to be included in the set of indicators to monitor the MDGs:

- Proportion of land area covered by forest
- Ratio of area protected to maintain biological diversity to surface area
- Energy use (kg oil equivalent) per $1 GDP (PPP)
- Carbon dioxide emissions (per capita)
- Consumption of ozone depleting CFCs (ODP tons)
- Proportion of population using solid fuels
- Proportion of population with sustainable access to an improved water source, urban and rural
- Proportion of urban population with access to improved sanitation
- Proportion of population with access to secure tenure (owned or rented)

The nine indicators were selected according to a number of selection criteria, of which the most important were that they *captured important environmental problems*, were *relevant for the majority of the countries in the world* (including developed countries), and that *data were available* (collection of new data was beyond the scope of the project). Furthermore, there was a limit to how many environmental indicators could be included in the total set of indicators for the MDGs.

The core set of indicators will be used—at a global level—to monitor performance and adjust development strategies as required. The World Development Indicators published annually by the World Bank, will report on the nine core indicators, making the information accessible world wide, and putting it in the front of the World Bank's priorities in its collaboration with other international partners.

Source: World Bank 2002.

outputs and impacts of certain activities in the area (that is, the project based framework can be used). Another difference between the international and the regional level (as well as the other, more disaggregated levels) is the possible focus on aspects (driving force, pressure, state, impact or response) of environmental problems instead of environmental themes.

National level

As soon as the initiative is at a less aggregated level, such as at the *national level*, the considerations differ a lot more. For example,

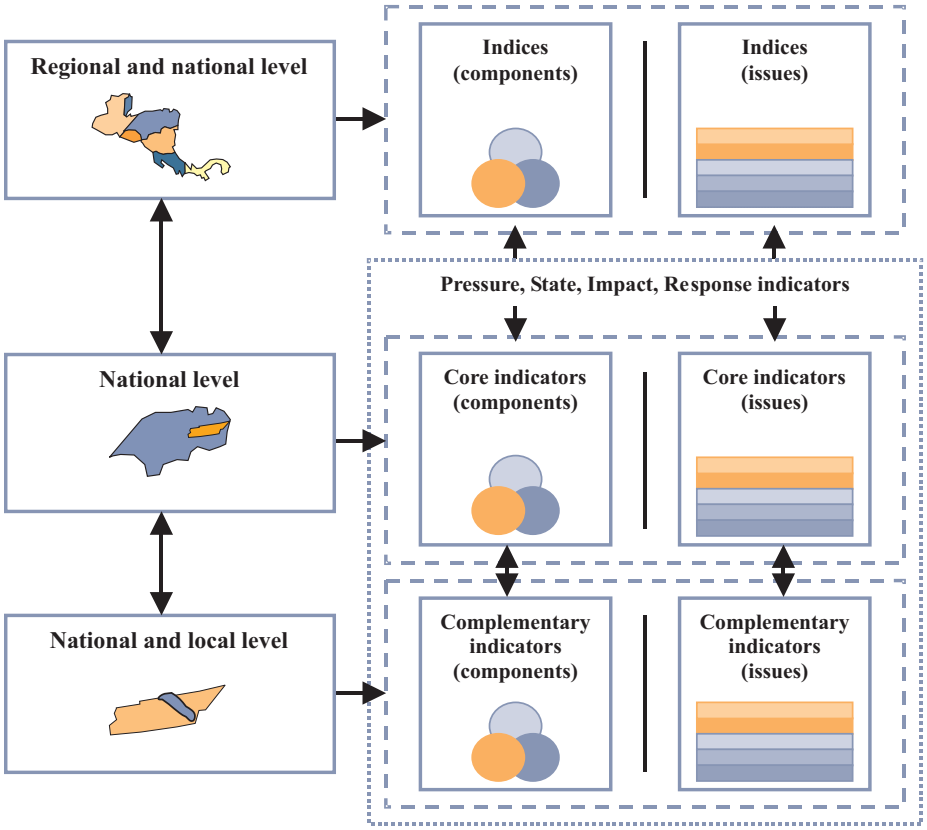
consensus may not be as important as the issues that are relevant for the development of the country. The national level initiatives are also more practical in their approach. Activities such as involvement of different national institutions and organizations, survey of national data bases, focused initiatives with regard to data collection and indicator development, surveys of information needs, and investigations in what decision-making processes that are not well supported by good quality information are therefore commonly in focus.

Local or project level

At the *local or project level* the initiatives become even more practical and action oriented. At this level, the initiative can really benefit from including a phase in which actions and recommendations on measures to implement are a central part. At the local level, the causal links are more easily ascertained, data collection and indicator development are built into the project and the monitoring objective is usually to identify outputs and impacts.

It is not always only one analytical level that is of importance for an initiative. To begin with, for example, a regional analysis and then continue to look at the details on a national or even local level can be very helpful. For such initiatives, flexibility is a central feature. Figure 8 depicts an example of a framework used in

Figure 8. Connecting the different analytical levels



Source: Segnestam and others 2000.

the CIAT-World Bank-UNEP collaborative project on indicators for rural sustainability in Central America. Many of the considerations mentioned above are included in this framework. The work with this framework started at the regional level where the issues to be covered by the initiative were discussed and agreed upon. Depending on the audience and situation, the indices and indicators can also be structured according to aspects of environmental problems. In the project, this approach was demanded in order to enable decision-makers to separate, for example, all potential underlying causes from all observed impacts. In addition, since the project dealt with rural *sustainability*, the project allowed the user to sort the indicators according to components (social, economic and environmental) and their interactions (socioeconomic, socio-environmental and economic-environmental).

Owing to this flexibility, various users at various analytical levels can find a use of the indicator initiative. The indices developed at the regional level can guide the regional decision-making, but it can also suggest what the national decision-makers should focus their investigations on. Finally, where available, local level data can help support in more detail various decisions and policy changes made based on the indicators included in the project.

Tools for Presentation and Analysis

When the indicators have been selected using a number of stringent selection criteria, it is time for collection, and finally analysis and presentation. Given the role of indicators as a basis for analysis, improvements in policy-making, and in informing and educating the general public as well as societies' decision-makers, the tools and manner used for analysis and presentation are important. There are many methods of presentation of indicators that can be used: textual presentations, graphs, numerical presentations, tables, and maps are some examples. In addition, it can be advantageous for the analysis to use comparators, baseline values, thresholds, and/or targets (for a summary of the use of baselines, thresholds, and targets, see Table 3).

Table 3. Baselines, thresholds, and targets

	For which activity	*When to use…*	*How to establish…*
Baseline	For any activity whose impacts one wishes to follow	To monitor environmental changes (positive or negative) due to an activity	When used for monitoring environmental change: establish baseline at initiation of activity.
			When used to illustrate total environmental change: set baseline at zero.
Thresholds	To control an activity that may have a negative environmental impact	To monitor negative impacts which should not exceed a pre-determined threshold	Establish threshold through determining the carrying capacity of the system.
Targets	For activities which aim to improve the state of environment or sustainable development	To monitor that positive environmental impacts of an activity are sufficiently large	Establishment depends on the objective of the activity.

Analytical aids

Baselines

For any indicator to be meaningful, either baselines, thresholds and/or targets for the indicators need to be established. A *baseline* is a value that is determined before an indicator initiative starts in order to show a positive or negative environmental change as a result of an intiative. Without a baseline, the indicator values detected as the monitoring continues can not be compared to anything meaningful; it is not possible to say whether things have improved or become worse. It is then difficult to establish what kind of impact an activity has had, or what kind of changes are occurring in a region, country, or area.

If the project's objective is not about improving the environmental conditions, but rather about another development initiative which needs to be monitored so that it does not degrade the environment, the baseline is best established through the monitoring of the project area at the initiation of the project (to establish the current state of environment). The same method to establish the baseline is used in those initiatives that wish to illustrate how that state of environment is improving. For those indicator initiatives that have as their objective to illustrate how the state of environment has changed in total, the baselines are established as zero (for example, extent of protected areas or total CO_2 emissions).

It can be worthwhile to point out that, for the interpretation of the change within the area to be correct, the baseline may not be enough to compare with. To be able to determine whether, for example, the project was the best alternative, the resulting values should be compared to the *alternative development scenarios*. That is, the alternative development path for the monitored area without the project may not have been a path of non-existing change. Whatever would have happened in the area without the project should therefore be kept in mind during the interpretation of the monitoring result.

Thresholds

For some monitoring systems the establishment of *thresholds* may be of even greater importance than that of baselines as a tool for analysis. Thresholds are useful in initiatives that do not necessarily have environmental improvements, or sustainable development, as their main objective. Instead, there may be possible negative impacts on the environment or the development could in some other way be unsustainable, and thresholds should therefore be included for those aspects. This is, for example, true for a monitoring system that is based on alarm and diagnostic indicators as discussed above in Box 3. Without such levels, there is no way of knowing when the alarm sounds or when to react to what the indicator reveals. As a result of years of research, such thresholds already exist for several indicators. However, there are still many indicators that are not currently being monitored in the world, and thresholds therefore need to be established before those indicators become meaningful. Those thresholds should be established in an objective manner so that the current management practices and resource uses can be related to them.

Targets

The use of *targets* is very similar to the use of thresholds. However, targets are used to improve the state of environment through actions such as improved natural resource management, reduced pollution levels, or increased institutional efficiency. In short, targets are useful in initiatives that have

environmental or sustainable development improvement as one of their objectives. Performance indicators are used to monitor the progress towards these targets. The Millennium Development Goals, as developed by the world community, are an example of such targets. Each of the eight areas monitored (poverty, education, gender equality, infant and child mortality, maternal health, HIV/AIDS, malaria and other diseases, environmental sustainability, and global partnership for development) has a related development goal established. In addition, each of the indicators used for the monitoring of the areas has individual goals. For many of the most common indicators at the national, regional and international levels, targets already exist in the form of international commitments or consensus. Examples include the World Health Organization's guidelines on availability of safe drinking water and water for sanitary means of excreta disposal (WHO estimates this amount to 20 to 40 liters of water per person per day located within a reasonable distance from the household (WHO, 1996)) or the World Conservation Union's target for protected areas (10 % of a country's surface). Other targets are best determined through the monitoring of an "unspoiled" part of the monitoring area, or even of another area (if it seems likely that the area that is to be monitored already has been changed from its original state).

Comparators

While baselines, thresholds and targets can be seen as a sort of *comparator*—the result of monitoring the indicator is compared to a predetermined baseline, threshold or target for that indicator—the concept of comparators is much wider than that. Comparators belong to the most basic but important tools for facilitating indicator analysis. In order to decide which comparator to use and what it should look like, the indicator which one wishes to analyze needs to be thought about. The first choice for this number is whether to present it as a relative or absolute number. The difference between the two is easily illustrated by the indicator "protected areas." If the number of hectares of protected land in a country is presented—for example 47,000 hectares in Argentina—it probably does not say much to most people. If, on the other hand, the hectares of protected land are compared to the total land area, the interpretation of the indicator is simplified as it can now be expressed as 1.7% protected land of total land area. For some people, this may still not say much—is this a small or a large share of protected land? To answer that question, a comparator is necessary.

The comparator should, quite clearly, be presented in the same way as the original indicator, that is as an absolute or relative number. The assessment of what comparator to use can further highlight the relative use of these two types. For example, if the absolute number of protected hectares discussed above is compared to the regional average of protected hectares, the extent of biodiversity protection in Argentina would not be well illustrated. The main reason for this is that some countries are so much larger than others—the number of protected hectares in Argentina can therefore be much higher than the protected hectares in another smaller country, even if the latter has protected a larger share of its land.

If, on the other hand, the relative number of protected hectares is compared to the regional average (7.3%) or the average of the income group that Argentina belongs to (5.7%), the picture becomes a lot clearer—Argentina is protecting a relatively small share of its land. These types of considerations are taken into

account in indicator publications such as the *World Development Indicators, World Resources Report* or *The Little Green Data Book* which present some of the indicators as absolute numbers and some as relative (see Table 4).

A second choice concerns the actual comparator. This is very much an issue of the message that the indicators are supposed to convey. In some cases, like in the case of some Argentinean indicators, a comparison with most of the other countries in the region may work more as an excuse not to work on the issues monitored since the Argentine values look above average (for example, Argentina's annual freshwater use is 2.8% of its total resources compared to 3.6% in Chile). In that case an average for a couple of developed countries may be more useful as comparators since Argentina is relatively highly developed for its region (using the same example as above, Canada's annual freshwater use is 1.6% of its total resources). However, one should keep in mind to select comparators that are relevant, that is comparators that face more or less the same circumstances.

Presentational and analytical tools

CHARTS, GRAPHS, TABLES, AND TEXT

One purpose of comparators is of course to be able to compare countries, regions or income groups with each other. Nonetheless, care should be taken not to end up in a situation where a country, for example, feels the need to defend itself rather than taking the comparison as a help in achieving a necessary change. Another reason to be cautious with comparisons between countries is the variations in measurement and monitoring methodologies, and definitions (OECD 1994). A lack of

Table 4. Comparators in *The Little Green Data Book*

Argentina*

Latin America & Caribbean			
	Argentina	LAC Region	Upper middle income group
Population (millions)	36	502	588
Urban population (% of total)	89.3	74.5	76.6
GDP ($ billions)	298	2,028	2,838
Agriculture			
Land area (,000 sq.km)	2,737	20,064	21,777
Fertilizer consumption (100 grams/ha of arable land)	333	812	928
Population density, rural (people per sq.km)	16	253	188
Biodiversity			
Nationally protected area (% of land area)	1.7	7.3	5.7
Water and sanitation			
Access to safe water (% of total population)	65	..**	..
Fresh water resources per capita (cubic meters)	27,865	27,393	..
Access to sanitation in urban areas (% of urban population)	80	..	..

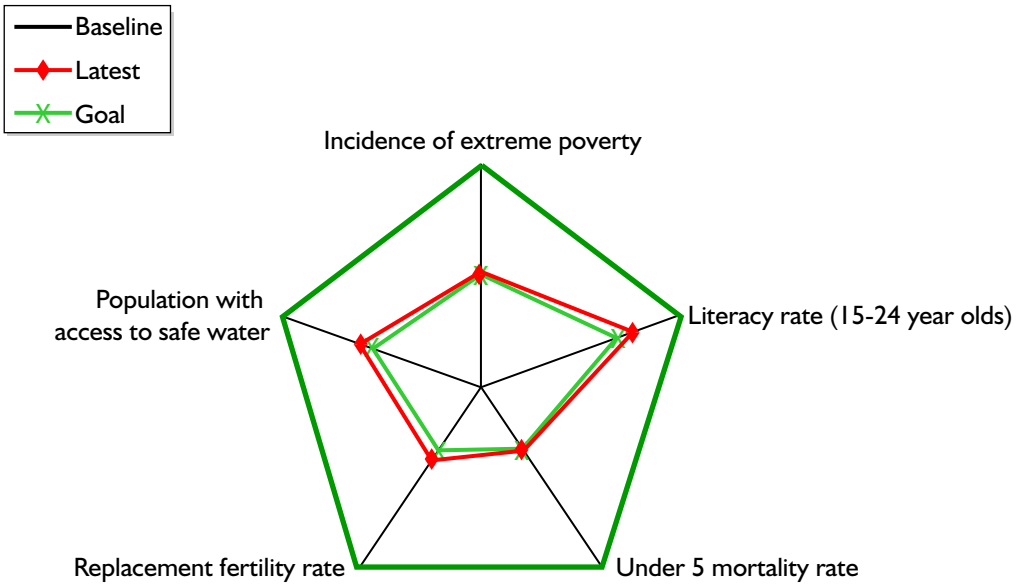
Notes: *The indicators listed here are a selection of those included in *The Little Green Data Book*.
** ".." — No data available.
Source: World Bank 2000.

standardization in such matters risks resulting in unfair and incorrect comparisons. Lists and tables such as the ones used in the *Little Green Data Book* easily invite people to rank countries and to make judgement on the countries that are lowest on the list. To avoid this, a number of visual tools can be used. One such example is the "indicator diamonds" used in the World Bank's *Country-at-a-glance* tables or in the work with the Millennium Development Goals (see Box 7). Figure 9 gives an example of this. Even though the individual countries' successes (or failures) in reaching the goals can be compared, this type of presentational tool makes the viewer focus more on the progress towards the standards for each country than to compare them with each other. Another way to avoid direct ranking is the use of quintiles. This enables a comparison between groups of countries, but the individual countries are not exposed.

A graph such as the data diamond is one tool for presenting indicators so that analyses and assessments are facilitated. The assessments are further facilitated if the diamonds are designed in such a way that an expansion (or reduction) is unambiguously positive (or negative, that is, a trend outwards is positive/negative) for each of the selected indicators. Other tools include other types of graphs and charts, tables, maps and text. Which tool one should use depends a lot on the type of indicator, the aim of the presentation and the audience. For example, text is best used when an indicator is qualitative and not quantitative. Text is sometimes also better when the audience are non-experts. The message that an indicator conveys may not be that clear to the general public if presented as a list of numbers.

Graphs and charts are also commonly useful when presenting monitoring results to an audience that is more interested in the overall message than in the details that the numbers can provide. They are per definition a visual tool and may, as such, be more communicative

Figure 9. Indicator diamonds as a tool for presenting the results — The example of Sub-Saharan Africa



Note: Baseline consists of data from 1990.
Source: OECD 2000b.

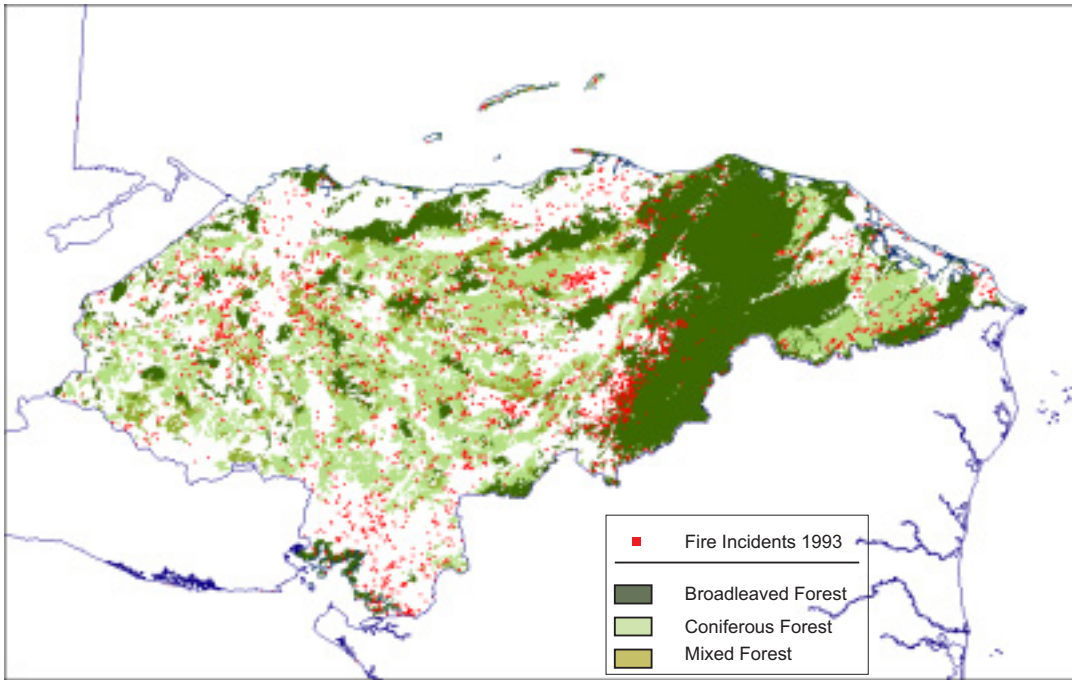
than a table. Tables, on the other hand, provide the user with more control over the numbers presented. Quality control is thus better enabled as are further analyses based on the numbers presented. There may also be a practical reason for using tables as they demand much less space in their presentation if several countries or regions are to be included.

Maps

One final tool for presentation and analysis is maps. Maps can be powerful as an analytical tool if used in the right context in a correct way. They are created either with the help of remote sensing, that is satellite images which give a picture of various aspects, for example forest areas, or with Geographic Information Systems (GIS). GIS is a computer-based system in which data (collected through any of the methods discussed above) are fed and mapped. It is commonly more useful for sub-national level data since data on a national level only results in a map covered in one color. At such a level, the analytical contribution of GIS does not differ from that of a graph. If data are available at a less aggregated level, however, analyses for different areas within a country, for example, are enabled. Take an indicator of deforestation as an example. If the data of deforestation are only available as one number for a whole country, it is not easy for a decision-maker to direct any reforestation actions since it is not clear where in the country deforestation is occurring. If, on the other hand, data are available at a sub-national level, a map can illustrate where the actions are needed.

The main advantage with maps is probably that they allow several indicators to be analyzed at the same time in an illustrative and easily comprehended way. One example of overlaying of indicators is presented in Figure 10. Two

Figure 10. Maps as a presentational and analytical tool



Source: Segnestam and others 2000.

different indicators have been included in the same map—forest type and fire incidents. If these two indicators would be presented in a table, or two separate graphs, it would be difficult to assess their interrelationship. Presented in a map, however, it is easier to visualize this relationship. Figure 10 shows how fire incidents in Honduras are more common in the areas that are not covered by forest.

Even though the use of GIS and the resulting maps can be very powerful both in their presentation and as an analytical tool, there are a number of aspects that any user should be aware of and cautious of. A summary of these aspects as well as of the main benefits of GIS is presented in Box 8.

Dissemination of Findings and Information

The participation of decision-makers and the public is necessary for the indicators to become useful. Without that participation, indicators will remain only a resource to be used. Participation can be achieved in many different ways. What method to select and use depends on various aspects such as the level of desired participation (only information sharing or active participation), desired impact of indicators (increased knowledge or increased use of information), who the audience is (general public, technical experts or policy-makers), and available means of dissemination.

Box 8
The Good and Bad with Geographic Information Systems

Advantages	*Disadvantages*
• An extremely visual tool for easy communication between developers and users • The only good tool for overlaying different indicators to enable analysis of several possibly interrelated aspects • GIS facilitate the superimposition and analysis of large amounts of data from different sources, simplifying the identification and analysis of potential interrelations between causes and effects of rural sustainable development issues • GIS enable the incorporation of, for example, socioeconomic, environmental, and sustainable development considerations into decisionmaking • GIS visualize data, indicators, and information at different analytical levels (regional, national, or local) • Significant spatial samples for indicators, or impartial averages for a geographically distributed sample of measures, can be obtained with the help of the geostatistic analysis capacity of GIS.	• The quality of underlying data risk become less apparent (a map looks more "real" than data in a table) • Data quality control is made more difficult since the data are "hiding" behind the map and are not always accessible to the viewer • Working with GIS demands resources in terms of money and competent personnel • Maps may lead the user to think there are causal links that in reality may not exist • A map is not able to show a relationship where the cause of a problem cannot be found within the same area as the impact (for example, the logging of tropical timber: the cause of the problem may lie in the demand from developed countries, while the deforestation problem occurs in developing countries). A table in comparison can be more flexible in including data from different parts of the world.

Source: Adapted from Segnestam and others (2000).

Web sites, CD-ROMs and publications belong to the more common dissemination tools used today. Both have the potential and advantage of reaching many. If the technology is there, there is hardly any tool that is as easily accessible and flexible as a web site. A CD-ROM as the one developed in the CIAT-World Bank-UNEP project on rural sustainability indicators for Central America (CIAT et al., 2000) is another tool with which data and indicators as well as various presentational instruments can be disseminated. If the technology is lacking, on the other hand, hard copies of findings, experiences and help are useful. For less "formal" information transfer, means such as posters, brochures, flyers and postcards have been used by various organizations.

These tools can also be used in a more interactive manner. Training material and courses can be developed for the Internet as well as for use in a classroom. What type of training one uses depends a lot on the audience—a decisionmaker may be in greater need of general information on the use of indicators while a technical expert commonly needs more support in the use and development of indicators and information. Considering this, individual training sessions with technical experts may result in greater impact.

No matter what the purpose of dissemination or who the audience is, some thought should be put into how to best convey the message to achieve the desired result. Several of the most commonly used and most effective tools of presentation have therefore been presented in the previous section.

4 Lessons Learned and Suggestions for Future Activities

Work on environmental and sustainable development indicators have, in many ways, come a long way in a few years time. However, as always when a new area of research is "discovered" and pursued, some aspects of the work has come much further ahead than others. Hence, there are still large knowledge gaps in the field of environmental indicators, and perhaps even larger in the area of indicators of sustainable development. Below follows a discussion in a summarized form on a selected number of these gaps as linked to some of the main lessons learned.

Theoretical Gaps — Do They Exist?

Over the years, the conceptual development behind environmental indicators has come far. The discussions continue on what framework to use, or which selection criteria, but on the whole, the stakeholders (technicians as well as decision-makers) seem to agree on what has been developed so far. None of the frameworks presented in this paper is perfect, but considering the diversity of contexts, issues, circumstances, and conditions that are relevant to take into account when monitoring the environment, it may not be feasible to develop a better framework than those existing. An important lesson learned is to *select among the existing frameworks carefully* depending on the issue analyzed and the level of analysis.

For the choice of selection criteria, the most important advice is to *be selective*. Indicators are all about indicating a change or direction of development, not about providing the complete answer.

Making the Instruments Work for You

In the same manner indicators should be used as an instrument to achieve higher ends, the instruments commonly related to indicator development discussed in this paper should be used as effectively as possible. Here, the lesson learned is: *be flexible*. The usefulness of the instruments depends on aspects as diverse as data quality and availability to the message that one wishes to convey. The different tools and instruments also differ in how far they have come in their development and what there is left to do:

- That the understanding of the role and purpose of baselines, thresholds and targets is increasing is clear. However, the practical use of the same needs to be taken farther. Targets for environmental indicators in an international context are still commonly lacking (for example, forest cover).
- The use of comparators in indicator work is becoming almost as common as the use of indicators themselves. However, the sense of what comparator to use when needs to be further refined.

- GIS is becoming very well developed technologically. The problem here is one of data quality and availability. In addition, for many countries in the world a well-developed use of GIS would require quite a lot in terms of infrastructure development. The use of tables, charts, graphs and text should therefore be emphasized also in the future. Their relative disadvantage to GIS in comparing relating, or "over-lapping", several indicators should, however, be highlighted.

Understanding the Link between Actions and Impacts

The link between cause and effect is still a mystery in many analyses. While indicators can be used to understand this link, many initiatives today seem to assume causal links that may or may not exist. In many cases, it is also difficult to establish the links clearly. This is, for example, a common problem with the project level framework discussed in this paper. While an observed output is easy to relate to the investments made and actions taken within the setting of the project, long-term impacts of the same investments or actions can be difficult to identify. Observed impacts can also be difficult to link to the project. The same analytical problems are often encountered in other types of initiatives where the purpose of the indicators is to see how one action leads, or does not lead, to an observed impact. *More research on causal links* are clearly needed, and indicators could be used in a more explicit way in that research.

From Green to Multicolored — The Issue of Complexity

There are groups of indicator initiatives that need more focus in the future such as those that *emphasize gaps in existing indicator sets of environmental aspects*, including indicators of institutional development, biodiversity and various cross cutting issues (for example, environment and poverty, environment and gender, environment and conflicts). Among the indicator initiatives that focus on cross cutting issues and that need special attention are those that *emphasize sustainable development* as opposed to environmental sustainability or change.

For many years, the concept of sustainable development has in many publications and contexts been used almost as a synonym to environmental sustainability or change. Indicators could potentially play an important role in widening the concept again to comprise social, economic, and environmental issues in interplay. Several initiatives of this sort are already underway. However, two lessons learned are that these initiatives are either too complicated to communicate, or do not manage to link the various components properly. Any composite indicator (or index) of sustainable development is likely to become complicated considering the nature of the concept of sustainable development. One suggestion for future activities could therefore be to focus more on the *interlinkages between social, economic and environmental aspects*, that is to analyze the linkages between those aspects in the indicator initiatives which encompass indicators of all three sorts. GIS could potentially be a powerful tool in such analysis.

An analysis of the interlinkages puts the issue of sustainability in the center. Most indicator sets of sustainable development consider a positive trend being sustainable. However, before the targets have been set according to *carrying capacity* (global, regional, national or local), it is difficult to establish what is sustainable. This

problem also needs to consider the issue of weighting the indicators against each other—can the development be sustainable if one indicator shows improvement and another deterioration?

Before any refining of the indicator work relevant to sustainable development will mirror the state of the world, the gaps in existing sets need to be filled. An emphasis on indicators of, primarily, institutional development, biodiversity and cross-cutting issues would help fill these gaps. Such an emphasis deals with different aspects depending on the issue. For example, the primary problem to overcome in the development of indicators of institutional development is probably the aspect of causal links and quality assurance. For biodiversity, it is more a financial aspect that plays a role—the ideal indicators have in many cases been identified, but it costs a lot to develop and maintain them. For the cross-cutting issues, the main missing aspect sometimes seems to be creativity. Many indicators, such as those of environmental vulnerability and accessibility to, for example, protected areas, have been developed, but perhaps not been put in the context of poverty, gender or conflicts.

Pushing the Practical Envelope

The largest gaps in current indicator work probably consist of the practical challenges that still need to be met and solved. One of these gaps has been stressed before, but is worth repeating—data collection and quality assurance are among the largest challenges that indicator developers face. Future work within this area could focus on a number of things depending on the level of development in the individual countries. In some countries, support may be needed to establish statistical offices in general; in others a special focus on environmental statistics may be what is lacking. Many countries that are already collecting environmental statistics would benefit from a review of what kind of statistics they should spend their resources on. The purpose of collecting data needs to be considered more in general since that is what guides, to a large extent, the type of support and development needed. For example, if the purpose of collecting data is to develop indicators that are internationally comparable, efforts on continuous monitoring, analysis, harmonization and quality assurance are needed.

Another necessary step into the practical world of indicators is to *interpret* the collected and developed indicators, to *transform this into information*, and to use that information to *improve decision-making processes*. Currently there is a risk of indicators becoming the tool that never left the desk of developers and technical experts. To take this step, several of the above suggested actions need to be taken. However, a few selected and well-analyzed pilot studies of how indicators have, or could be, used to create information to base decisions on, could further highlight existing knowledge gaps and function as support for future initiatives. While the UNCSD-initiative has carried out tests in 22 countries, the focus has been mainly on monitoring progress on sustainable development strategies, policies and activities (UN, 2000; Pretorius et al, 1998). Similar test studies on indicators as a basis for decision-making would be of equal value. Such test studies do not have to be carried out at a national level or in several countries. Analytical examples of indicator and information use could be performed at any level of analysis in basically any context and still contribute with several helpful hints on practical solutions on how to achieve the greatest results.

Listening to the Audience

A final lesson learned and recommendation for future practical work with indicators is to remember that different audiences, contexts, and ends need different indicators. Target groups for the indicator initiatives are seldom discussed explicitly. This risks resulting in an aim to identify conceptual frameworks, indicators, and analytical/presentational tools that are relevant to all different categories of audiences. Such an aim commonly fails in reaching several target groups, and one is often better off designing different indicator initiatives for different target groups. Therefore, make sure you know your target group, why they wish to use indicators and for what before deciding on framework, indicators, and analytical and presentational tools.

Appendix A
Outputs of the World Bank's Environment Department's Work Program

(*For more information visit* http://www.worldbank.org/environmentaleconomics)

CIAT, World Bank & UNEP. 2000. *Indicadores de sustentabilidad rural: Una vision para América Central*. CD-ROM. The World Bank: Washington DC; CIAT: Cali, Colombia; UNEP: Mexico City.

CIAT, World Bank & UNEP. 2000. *Developing Indicators: Lessons Learned from Central America*. Poster. Part of publication package on rural sustainability indicators for Central America.

Chinese State of Environmental Protection Administration. 1999. *China Urban Environmentally Sustainable Development Indicator Handbook: The Case of Sanming and Yantai*. Prepared by the China Sustainable Urban Development Indicator Project Team, China Environmental Science Press.

Hamilton, K. 2000. *Genuine Saving as a Sustainability Indicator*. Environment Department Papers, No. 77. The World Bank: Washington, DC.

Hazell, P., Chakravorty, U., Dixon, J.A., & Celis, R. 2001. *Monitoring Systems for Managing Natural Resources: Economics, Indicators, and Environmental Externalities in a Costa Rican Watershed*. EPTD Discussion Paper No. 73. IFPRI & the World Bank: Washington, DC.

Henninger, N., Hammond, A. 2002. Environmental Indicators Relevant to Poverty Reduction. Environment Strategy Series No. 3. The World Bank: Washington, DC.

Kunte, A., Hamilton, K., Dixon, J. & Clemens, M. 1998. *Estimating National Wealth: Methodology and Results*. Environment Department Papers, No. 57. The World Bank: Washington, DC.

Linddal, M. in collaboration with Winograd, M., Aguilar, M. & Farrow, A. 1999. *Forest Sector Indicators: An Approach for Central America*. The World Bank: Washington, DC.

Segnestam, L. 2001. *Indicators for a Policy Relevant Monitoring System* Hazell, P., Chakravorty, U., Dixon, J.A., & Celis, R. 2001. *Monitoring Systems for Managing Natural Resources: Economics, Indicators, and Environmental Externalities in a Costa Rican Watershed*. EPTD Discussion Paper No. 73. IFPRI & the World Bank: Washington, DC.

Segnestam, L. 1999. *Environmental Performance Indicators, A Second Edition Note*. Environment Department Papers, No. 71. The World Bank: Washington, DC.

Segnestam, L. in collaboration with Winograd, M. & Farrow, A. 2000. *Developing Indicators: Lessons Learned from Central America*. The World Bank: Washington, DC.

Shyamsundar, P. 2001. Poverty-Environment Indicators. Environment Department Papers, No. 84. The World Bank: Washington, DC.

Winograd, M., Aguilar, M., Farrow, A. & Segnestam, L. 2000. *Conceptual Framework for the Development and Use of Water Indicators*. The World Bank: Washington, DC.

World Bank. 1997-2002. *World Development Indicators*. Development Data Group, The World Bank: Washington, DC.

World Bank. 1997. *Expanding the Measure of Wealth. Indicators of Environmentally Sustainable Development*. Environmentally Sustainable Development Studies and Monographs Series, No. 17. The World Bank: Washington, DC.

World Bank. 2000. *The Little Green Data Book*. Development Data Group in collaboration with the Policy and Economics Team (Environment Department), The World Bank: Washington, DC.

World Bank, CIAT & UNEP. 2001. *Rural Sustainability Indicator Project*. http://www.ciat.cgiar.org/indicators/index.htm. The World Bank: Washington DC; CIAT: Cali, Colombia; UNEP: Mexico City.

In addition, a number of indicator outputs have been part of more general initiatives. Examples include:

Millennium Development Goals — Nine environmental indicators were selected as part of the Millennium Development Goals (MDGs). The MDGs are monitored by a number of economic, social and environmental indicators that have been selected through an internationally collaborative effort. Main partners are OECD/DAC, various UN agencies and the World Bank.

CASE indicators — An indicator page was developed as part of the Country Assistance Strategies and the Environment (CASE) initiative for incorporation in the World Bank's Country Assistance Strategies;

UN Commission on Sustainable Development — Indicators for the measurement of sustainable development. The Bank's Environment Department has been part of the expert group advising the work on the CSD indicators.

Appendix B
Selected Examples of other Organizations' Work

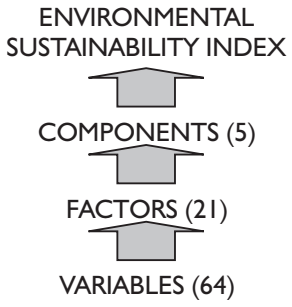
This appendix presents a selected number of examples of indicator initiatives from other organizations' work than the World Bank's. They have been selected since they illustrate the different paths one can choose in developing indices or indicator sets for environmental aspects and sustainable development respectively. However, it may be worth pointing out that there exist many more initiatives, and the usefulness of each of them depend entirely on the context and wish of the user. Therefore, the below presented initiatives should not be viewed as particularly recommended for use in all contexts.

Environmental Indicators

I. Aggregated

The Ecological Footprint. The Ecological Footprint is a method for estimating the biologically productive area necessary to support current consumption patterns, given prevailing technical and economic processes. By comparing human impact with the planet's limited bioproductive area, this method tests a basic ecological condition for sustainability. The Ecological Footprint calculations have so far included land for energy supply, food, forest products, and the built environment, degraded areas, and sea space for fishing. For the waste side the land needed for sequestering CO_2 is included in the Ecological Footprint. (Holmberg et al., 1999)

Pilot Environmental Sustainability Index. The Pilot Environmental Sustainability Index is constructed in a hierarchical fashion (see figure to the right). The five components describe the current environmental systems; stresses to those systems; the vulnerability of human populations to environmental disturbances and disasters; the social and institutional capacity to respond to environmental problems; and global stewardship, or the degree to which an economy behaves responsibly with respect to other economies. These components consist of a number of factors (for example, urban air quality, air pollution, basic sustenance, science and technical capacity, and contribution to international cooperation) considered to constitute the most fundamental building blocks of each component. For each factor, variables (for example, urban NO_2 and SO_2 concentration, SO_2 and NO emissions per land area, percentage of households with electricity, scientific and technical articles per million populations, and number of memberships on environmental intergovernmental organizations) are identified to serve as measures. (World Economic Forum 2000)



Living Planet Index. The Living Planet Index (LPI) is an index which primarily measures abundance – the area of the world's forests and the populations of different marine and freshwater species. Thus it is essentially measuring natural wealth and, particularly, how this natural wealth has changed over time. The LPI is an aggregate of three different indicators of the state of natural ecosystems. These are: the area of natural forest cover around the world, populations of freshwater species around the world, and populations of marine species around the world. (WWF, NEF & WCMC, 1999)

II. Sets of indicators

OECD core set of environmental indicators. In 1994, the OECD Environmental Policy Committee finalized the first part of a three-part work program. They developed a core set of environmental indicators to be used in environmental performance reviews in OECD countries (all indicators are based on available data). The indicators are structured by environmental issues, which reflect environmental challenges. The list of issues proposed was never meant to be final nor exhaustive, but rather flexible where new issues can be incorporated or old ones abandoned according to their environmental relevance.

Broadly speaking, the first nine issues (climate change, ozone layer depletion, eutrophication, acidification, toxic contamination, urban environmental quality, biodiversity, landscape, and waste) can be considered "sink-oriented", dealing with issues of environmental quality, whereas the other issues (water resources, forest resources, fish resources, and soil degradation) are "source-oriented", focusing on the quantity aspect of natural resources. Not all indicators can be directly associated with a specific environmental issue (for example, population growth or economy-wide environmental expenditure). A category of general indicators has therefore been introduced in the framework. (OECD 1994.)

Environmental Pressure Indicators. Eurostat (the statistical department of the EU) has developed a consistent and comprehensive system of environmental pressure indicators. They show the important trends for ten policy fields: air pollution, climate change, loss of biodiversity, marine environment and coastal zones, ozone layer depletion, resource depletion, dispersion of toxic substances, urban environmental problems, waste, and water pollution and water resources. The framework used is the Driving force-Pressure-State-Impact-Response model described earlier in this paper. The possibility of condensing these indicators into ten indices, one for each policy field, is being explored. (TAU and EMAIL 2001.)

Material Flows. Because all environmental problems are ultimately related to flows of materials, World Resources Institute is developing indicators that capture a picture of the material flows through industrial economies: industrial minerals, construction materials, metals, chemicals, infrastructure, fossil fuels, soil erosion, renewables, semi-manufactures, finished products, and the hidden flows (WRI 2000). Material flow accounting can systematically track the physical flows of natural resources through extraction, production, fabrication, use and recycling, and final disposal, accounting for all losses along the way. This technique is motivated by the desire to relate the use of natural resources to the capacity of the environment to provide the materials and absorb the wastes. (Adriaanse and others 1997.)

Sustainable Development Indicators

I. Aggregated

The Genuine Progress Indicator. In 1995, Redefining Progress created a more accurate measure of progress, called the Genuine Progress Indicator. It starts with the same accounting framework as the GDP, but then makes some crucial distinctions: It adds in the economic contributions of household and volunteer work, but subtracts factors such as crime, pollution, and family breakdown. Because the GDP and the GPI are both measured in monetary terms, they can be compared on the same scale. (Redefining Progress 1999.)

The Barometer of Sustainability. The Barometer of Sustainability is a tool for combining indicators and displaying the results. It presents indices visually, providing anyone—from villager to head of state—with an immediate picture of human ecosystem wellbeing. It can portray changes in the indices over time and compare the indices of different societies. The Barometer's key features are:

- Two axes, one for human wellbeing, the other for ecosystem wellbeing. This enables each set of indicators to be combined independently, keeping them separate to allow analysis of people-ecosystem interactions.
- The axis with the lower score overrides the other axis. This prevents a high score for human wellbeing from offsetting a low score for ecosystem wellbeing (or vice versa)—reflecting the view that people and the ecosystem are equally important and that sustainable development must improve and maintain the wellbeing of both.
- Each axis is divided into five bands. This allows users to define not just the end points of the scale but intermediate points as well, for greater flexibility and control of the scale. (Prescott-Allen 1999.)

II. Sets of indicators

Indicators of Sustainable Development (UNCSD). At its Third Session in 1995, the Commission on Sustainable Development (CSD) initiated the development of indicators for the measurement of sustainable development. A working list of 134 indicators was selected and 22 countries volunteered to test their applicability. By the year of 2001, the aim is to have a standardized set of indicators available as a tool to measure progress toward sustainable development. This tool will be available to all countries in order to support high-level decision-makers in their process of defining their national plans towards sustainability. (UNCSD, 2000) For more information on the themes covered by the set, see Table 1.

Appendix C
How to Develop a Set of Indicators

Indicator initiatives can, as discussed in this paper, fulfill many different uses. They can also be developed in a participatory or non-participatory manner. The following steps describe the actions taken in the most common indicator initiatives.[3] They also distinguish between those needed for a participatory initiative, or for the different purposes of the initiatives (monitoring of progress or degeneration, monitoring of outputs/impacts, and establishment of causal links).

- *Development and harmonization of a framework to organize the information.* A framework needs to be developed, or agreed upon, to be able to structure *what* is to be monitored, the *interlinkages* between the monitored aspects, and the *identification of possible actions* to influence the observed trends and developments;
- *Definition of selection criteria, indicator sets, and analytical methods/tools.* For the clarity of the initiative as well as to make it communicable to various stakeholders, selection criteria need to be established and agreed upon. Based on the framework and the identified selection criteria, a set of indicators and indices can be identified. The tools used in the analysis of the forthcoming monitoring results are necessary to identify and develop – without such tools it is not possible to explore the dynamics and impact of policies, action, and strategies in the developmental processes or to identify and analyze cause-effect relationships;
- *Establishment of participatory/consultative network.* If a participatory method is desired, it should be established fairly early on in the process. For several types of projects (particularly those that aim to affect decision-making processes at various levels), participation of institutions and people is crucial for the sustainability of the project. Activities that have been tried in the establishment of networks include workshops in which goals and needs are identified and where participating organizations and groups can meet, visits to the various participants to obtain participation, harmonize activities, identify contact people, exchange results, and training in indicator development and use;
- *Data search and development of databases for the indicator sets and analytical tools.* After having considered all the conceptual aspects in indicator development, the practical phase begins. A survey of existing databases (availability, production and use of data, unmet needs, and the timing for needed data can all be included in the survey), development of actual indicators and indices and the application of the selected analytical tools are part of this phase. The application of the analytical tools may have to wait for new data to be

collected and, based on that data, indicators to be developed;

The following four steps may not be relevant for all kinds of indicator initiatives. Primarily, they are vital in initiatives which either aim to have an impact on decision-making processes, or that is more research-based and need to be validated.

- *Development of capacities and tools to visualize information and analyze cause-effect relationships.* For the information obtained through analyses of the data, indicators and indices to play a role in existing decision-making processes, it needs to be presented in a way that i) enables analysis of causal links, and ii) visualizes the results of such analyses. If the results are not communicable, the information obtained is unlikely to convince any decision-maker to change current practices;
- *Development of test studies for the validation of project results.* If the fourth step above ('Data search and development of databases for the indicator sets and analytical tools') does not entail practical work in relation to, for example, a project, the findings from the first steps need to be validated. Without such validation, the implementation at a later stage may not be feasible and the selected indicators may not be applicable. The selection of test studies needs to be based on the purpose of the project. They should also focus on the same analytical level as the aim of the project;
- *Dissemination of information and tools.* Another vital step is the dissemination of project results, testing results and the tools necessary for the project to be replicable in other parts of the world. Tools for dissemination has been discussed in this paper, and should first and foremost take into consideration the various obstacles and possibilities faced by various groups and countries; and
- *Design of actions and implementation.* Finally, since indicators are only the means to an end, the indicator initiative could include a step of designing actions, mitigating measures and the implementation of the same. This step is crucial for the success and meaningfulness of an indicator initiative, but does not have to be part of the initiative per se. The dissemination of information and tools can be the step, which triggers this part even if it is not within the scope of the monitoring initiative. If the indicator project is well designed, the development of actions and mitigating measures should follow quite easily. The relatively large challenge lies in the implementation of the same since it demands resources, political willingness, and further monitoring.

Notes

1. In this paper, *a group of countries* are referred to as a region (a region is thus not an area *within* a country). Furthermore, even though a region as defined in this paper is an international area, a distinction is made between analyses or initiatives at the regional level and at the international level (meaning analysis and initiatives relevant for as many countries as possible in the world). The reason for this distinction is the difference in how methodologies and practical considerations matter for the two levels.
2. The Project Concept Document (PCD) defines the rationale for a proposed investment operation and the framework for its preparations, and flags issues or areas of special concern to the Bank. It serves as the basis for a Bank decision to assist a borrower with project preparation in the early stages of the project cycle. The PCD later evolves into the Project Appraisal Document.
3. The steps in the evolution of an indicator project are adapted from Segnestam and others (2000).

References

Adriaanse, A., Bringezu, S., Hammond, A., Moriguchi, Y., Rodenburg, E., Rogich, D. & Schütz, H. 1997. *Resource Flows: The Material Basis of Industrial Economies*. World Resources Institute: Washington, DC, USA; Wuppertal Institute: Wuppertal, Germany; Netherlands Ministry of Housing, Spatial Planning, and Environment: The Hague, Netherlands; National Institute for Environmental Studies: Tsukuba, Japan.

Baltic Environment Forum. 1998. *Baltic State of the New Environment Report based on environmental indicators*. In collaboration with Estonian Environmental Information Centre, Latvian Environment Data Centre, Latvian Environmental Consulting and Monitoring Center, Joint Research Center, Lithuanian Ministry of Environmental Protection. Printing House <<Gandrs>> Ltd.: Latvia.

Bossel, H. 1999. *Indicators for Sustainable Development: Theory, Method, Applications. A Report to the Balaton Group*. International Institute for Sustainable Development: Winnipeg, Canada.

CIAT (International Center for Tropical Agriculture). 2000. *Analysis of Natural Disaster Vulnerability for Honduras*. Powerpoint presentation. The International Centre for Tropical Agriculture: Cali.

CIAT, World Bank, and UNEP. 2000. *Indicadores de sustentabilidad rural: Una vision para América Central*. CD-ROM. The World Bank: Washington DC; CIAT: Cali, Colombia; United Nations Environment Programme: Mexico City.

Economic and Social Commission for Asia and the Pacific. 1997. *Towards Indicators of Sustainable Development in Asia and the Pacific*. United Nations: New York, USA.

Hammond, A., Adriaanse, A., Rodenburg, E., Bryant, D., and Woodward, R. 1995. *Environmental Indicators: A Systematic Approach to Measuring and Reporting on Environmental Policy Performance in the Context of Sustainable Development*. World Resources Institute: Washington, DC, USA.

Holmberg, J., Lundqvist, U., Robèrt, K-H., and Wackernagel, M. 1999. 'The ecological footprint from a systems perspective of sustainability'. *International Journal of Sustainable Development and World Ecology*, vol. 6: pp. 17-33.

OECD (Organisation for Economic Co-operation and Development). 1994. *Environmental Indicators. OECD Core Set*. OECD: Paris, France.

_____. 2000a. *Frameworks To Measure Sustainable Development*. OECD: Paris, France.

_____. 2000b. *Development Indicators. Sub-Saharan Africa: Five Dimensions of Development*. http://www.oecd.org/dac/indicators/htm/rcha_ssa.htm

Prescott-Allen, R. 1999. *System Assessment Method. Origins and Key Features*. The World Conservation Union: Washington, DC, USA.

Pretorius, R., Grobler, L., and Moore A., eds. 1998. *Results From Testing of CSD Indicators of Sustainable Development in South Africa: 1998.* Report to the United Nations Commission on Sustainable Development. Department of Environmental Affairs and Tourism: Pretoria, South Africa.

Redefining Progress. 1999. *The Genuine Progress Indicator*. http://www.rprogress.org/progsum/nip/gpi/gpi_main.html

Reid, W.V., McNeely, J.A., Tunstall, D.B., Bryant, D.A., and Winograd, M. 1993. *Biodiversity Indicators for Policy-Makers.* World Resources Institute: Washington, DC, USA.

Segnestam, L. 1999. *Environmental Performance Indicators: A Second Edition Note*. Environment Department Papers No. 71. The World Bank: Washington, DC, USA.

Segnestam, L., in collaboration with Winograd, M., and Farrow, A. 2000. *Developing Indicators: Lessons Learned from Central America*. The World Bank: Washington, DC, USA.

TAU and EMAIL. 2001. *Towards environmental pressure indicators for the EU – Second edition 2000.* TAU Consultora Ambiental and Environment Management And Information Liaison: Spain and the Netherlands.

UN. 2000. *The CSD Work Programme On Indicators Of Sustainable Development*. Addendum to Report of the Secretary General on Information for Decision-Making and Participation. E/CN.17/2001/_/Add.1. UN Economic and Social Council: New York, USA.

UNDSD. 2000. *Report of the Consultative Group to Identify Themes and Core Indicators of Sustainable Development*. New York, 6-9 March 2000. UN: New York, USA.

_____. 2001. *Indicators of Sustainable Development: Framework and Methodologies.* Commission on Sustainable Development, Ninth Session, 16-27 April 2001. Background Paper No. 3. UN: New York.

UNEP. 1999. *GEO-2000. UNEP's Millennium Report on the Environment.* Earthscan Publications Ltd.: London, UK.

US Interagency Working Group on Sustainable Development Indicators,. 1998. *Sustainable Development in the United States. An Experimental Set of Indicators*. Washington, DC, USA.

Virtual Research and Development Centre. 2001. *Livestock and Environment Toolbox*. http://lead.virtualcentre.org/en/dec/toolbox/homepage.htm

WHO (World Health Organization). 1996. *Water and Sanitation*. Fact sheet No. 112. http://www.who.int/inf-fs/en/fact112.html

Winograd, M., Fernandez, N.F., and Farrow, A. 1998. *Tools for Making Decisions in Latin America and the Caribbean*. CIAT: Cali, Colombia; UNEP: Mexico City, Mexico.

Winograd, M., Aguilar, M., Farrow, A., and Segnestam, L. 2000. *Conceptual Framework for the Development and Use of Water Indicators*. The World Bank: Washington, DC.

World Bank. 1999. *Lesotho. Maloti Conservation and Development Project*. Project Concept Document. Africa Regional Office, The World Bank: Washington, DC, USA.

_____. 2000. *The Little Green Data Book. From the World Development Indicators*. The World Bank: Washington, DC, USA.

_____. 2002. *Millennium Development Goals 2002. From the World Development Indicators*. The World Bank: Washington, DC, USA.

World Economic Forum. 2000. *Pilot Environmental Sustainability Index. An Initiative of the Global Leaders for Tomorrow Environment Task Force, World Development Forum*. In collaboration with Yale Center for Environmental Law and Policy, and Center for International Earth Science Information Network. Annual Meeting 2000. Davos: Switzerland.

WRI (World Resources Institute). 2000. *Developing environmental indicators: Materials ecology*. http://www.wri.org/matecology/index.html

WWF, NEF, and WCMC. 1999. *Living Planet Report 1999.* WWF International: Gland, Switzerland.