A Guide to the Assessment of Biological Diversity

DRAFT

Developed by

The IUCN M&E Initiative
and
The IUCN Biodiversity Policy and International Agreements Unit

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About this Guide

This guide describes a method of assessing biodiversity for use by:

1. Focal points of the Convention on Biological Diversity (CBD) and organizations working with them. The purpose is to help them—
   a. Assess the implementation and effectiveness of their strategies, plans, programmes, policies and actions to implement the CBD and to conserve and use biodiversity sustainably [Article 6].
   b. Implement Article 7 on identification and monitoring.
   c. Report on measures to implement the provisions of the CBD and their effectiveness in meeting the CBD's objectives [Article 26].
2. Other organizations wishing to assess the status and trends of biodiversity, human stresses on biodiversity, and benefits from biodiversity—
   a. As part of a national, provincial/state, or local assessment of sustainable development, such as an Agenda 21 report.
   b. As part of a thematic or sectoral assessment, such as on forests, desertification, marine, wetlands, etc.

The aim of the guide is to help users build their capacity to assess biodiversity, improve their information on biodiversity, and apply their assessments to better decision-making and action.

IUCN and partner agencies invite National delegations to the CBD COP and collaborating NGOs to use the Guide and through its use to improve the approach and method. For more information please contact IUCN at - marta.chouchena-rojas@iucn.org

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1. Introduction

At the Fifth Meeting of the Subsidiary Body on Scientific, Technical and Technological Advice, Parties to the Convention on Biological Diversity discussed the issues of indicators and national reporting at some length. Parties indicated that a menu-driven approach, one that maximized flexibility for selecting indicator most relevant to their national situations. Parties also noted a general lack of capacity and requested the development of a guide for assessing biological diversity and training materials.

The need for biodiversity assessment

As defined by the Convention on Biological Diversity (CBD), biological diversity is "the variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part, diversity within species, between species, and of ecosystems" [Article 2]. Throughout this guide, biological diversity is shortened to biodiversity.

Assessing the status and trends of biodiversity is essential for sustainable development strategies at all levels, from village to nation to region. Biodiversity is crucial for the wellbeing of people and the Earth. Ecological communities maintain the ecological and evolutionary processes that sustain life. These are necessary to help maintain the planet's chemical balance, moderate climate, renew soil, and conserve species diversity. Plant, animal and other species have intrinsic worth. They are also the source of all biological wealth—supplying food, raw materials, medicines, recreational resources, and a store of other goods and services worth many billions of dollars per year. The genetic stocks within crop varieties, livestock breeds and their wild relatives provide essential traits for increasing and improving agricultural production and the development of biotechnologies.

The role of Assessment in the Convention on Biological Diversity (CBD)

Assessment is necessary to ensure that actions implement plans and policies and achieve objectives. Assessment has a key role in the CBD, since it is the means by which the Parties and others can determine how fully the CBD is being implemented; what difference implementation is making to ecosystem, species and genetic diversity; and what still needs to be done.

Assessment is necessary to ensure that the strategies, programmes and policies provided for in Article 6 are implemented and achieve the results expected of them. It is also needed to provide basic information on biodiversity (status, stresses, benefits) required for Article 14 on impact assessment and minimizing adverse impacts.

The CBD calls specifically for identification and monitoring in Article 7—in particular to determine progress with *in situ* conservation [Article 8], *ex situ* conservation [Article 9], and sustainable use of components of biodiversity [Article 10]. It provides for the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) to assess the status of biodiversity and the effects of measures taken to implement the Convention [Article 25]. Finally, the CBD requires Parties to report on measures to implement the provisions of the CBD and their effectiveness in meeting the CBD's objectives [Article 26]. When assessment is a regular part of the planning and action cycle (Figure 1.1), reports contribute to better decision making and effective implementation and are easy to prepare. In the absence of regular assessment, reports can become burdensome and irrelevant.

These requirements are elaborated by decisions of the Conference of the Parties, notably COP2 [Decision 2/17], COP3 [Decision 3/10], and COP4 [Decision 4/1]. Table 1.1 summarizes the decisions and shows where they are covered in this guide.

COP decisions	See
COP2/17 suggests that national reports by Parties include monitoring and evaluation of:	
the results of the national strategy, plan or programme for conservation and sustainable use of biodiversity	Chapter 2, sections B + C
changes in the economy, environment and society	Annex 1
COP3/10 urges Parties to identify indicators of biodiversity	Chapter 2, sections B + C
Recommends step-by-step implementation of Article 7, beginning with rapid implementation of 7 (a) and the first part (identification) of 7 (c)	Chapter 2, sections B + C
and endorses SBSTTA recommendations II/1 and II/2. SBSTTA II/1 identifies eight priority tasks: Capacity building, strengthening of institutions and funding in developing countries [including capacity-building for taxonomy—SBSTTA II/2]	Annex 1
Development of the clearing house mechanism to improve the flow of information	not covered
Development/refinement of national guidelines on assessment and monitoring methods and indicators	Annex 1
a critical review of methods of inventory and assessment	to be prepared after testing this guide
Development of a core set of indicators that are known to be operational, for national reports	Chapter 2, sections B-D
Development of indicators in thematic areas important to the CBD, particularly coastal and marine ecosystems, agricultural biological diversity, forests, and freshwater ecosystems	Chapter 2, sections B-D
Development of an indicative framework of categories of activities with significant adverse impacts on biodiversity	Chapter 2, section C
Development of methods to include assessment of biodiversity in assessments of natural resources (forests, land, soils, marine living resources)	Chapter 2, sections B-D
COP4/1 proposes that further work on indicators take account of development of the ecosystem approach	Chapter 2, section B
and endorses SBSTTA recommendation III/5. SBSTTA III/5 requests: a key set of standard questions	Chapter 2
a set of principles for designing national-level monitoring programmes and indicators	Annex 1
a menu of possible approaches, a synthesis of best practice and lessons from case studies	to be prepared after testing this guide
Emphasis on capacity-building in indicator development and application	Annex 1

Table 1.1. CBD Conference of Parties (COP) decisions on assessment (including identification and monitoring) and their location in this guide.

According to these Articles and Decisions, assessment should cover the major topics shown in Table 1.2 (below). This is a challenging task because:

1. Taking a clear and easily communicated snapshot of something so rich in detail and so complex is technically arduous. The difficulties include choosing issues that are both informative and accessible, deciding which (if any) of the available indicators best represent the issues, interpreting the indicators, and synthesizing the results without losing essential information.
2. Besides being scientifically and technically sound, assessments need to be useful for decision-making. This entails ensuring they relate directly to current or imminent policy concerns, and can be readily translated into proposals for decision and action.
3. The components of biodiversity are innumerable, span a wide range of spatial and taxonomic levels, and interact with each other and with human societies and economies in intricate and ever-changing ways. Determining the status and trends of the components, and of the flow of threats and benefits, is potentially extremely expensive and time consuming.
4. Human and financial resources are at a premium even in wealthy countries. Most countries are hard pressed to undertake even the most basic of assessments. Therefore, assessments need to rely on a small, manageable and cost-effective set of indicators, and on a practical information system that can be developed gradually.
5. Assessments are required for other conventions (CITES, Wetlands, World Heritage, Migratory Species, Desertification, Climate Change, Regional Seas, etc.), for reporting on Agenda 21 to the United Nations Commission on Sustainable Development, and for a variety of other purposes. The scope of many of these assessments overlaps with the scope of assessments needed for the CBD. Similarly, local, provincial and national development and conservation plans and projects often require the collection and analysis of information on components of biodiversity, and many private and voluntary organizations have significant monitoring programmes. It would be sensible to take advantage of shared interests and data requirements, and avoid duplication.

Topic	**CBD Article**	**See**
Components of biodiversity especially those requiring urgent conservation measures or which offer the greatest potential for sustainable use	7 (a), 7 (b)	Chapter 2, section B
Processes and categories of activities which have or are likely to have significant adverse impacts on the conservation and sustainable use of biodiversity	7 (c)	Chapter 2, section C
Maintenance and organization of data derived from identification and monitoring activities	7 (d)	Annex 1
Measures taken for the implementation of the provisions of the CBD	26	Chapter 2, section D
Their effectiveness in meeting the objectives of the CBD:	26	

Conservation of biodiversity	1	Chapter 2, sections B + C
Sustainable use of its components	1	Chapter 2, section C
Fair and equitable sharing of the benefits arising out of the utilization of genetic resources	1	Chapter 2, section C

Table 1.2. Topics to be covered by assessment and reporting on the CBD and their location in this guide.

The Approach in this Guide to Assessing Biodiversity

To address these challenges, this guide describes an approach and a framework for biodiversity assessment, which would provide information necessary to:

- Enable Parties to the CBD to design and carry out effective and efficient policies to achieve the objectives of the Convention;
- Facilitate reporting on measures taken to implement the provisions of the Convention;
- Enable the Parties to assess the effectiveness of such measures in meeting the objectives of the Convention;
- Provide a tool for management of biodiversity at local and national levels.

The assessment method is intended to:

- Recognize that circumstances in each country will differ;
- Be feasible to implement with available resources;
- Be within each country's current capacity for identification, monitoring, and reporting;
- Make full use of resources and skills at all levels, and help to increase resources and improve skills;
- Be expandable as more resources become available and greater capacity is developed;
- Contribute to, and benefit from, development of a national information system;
- Contribute to, and benefit from, other assessments, including full system (sustainable development) assessments, State of Environment Reporting, assessments and reporting for other conventions, sectoral resource assessments, project assessments, and environmental impact assessments.

The need for practical advice

This guide recognizes that Parties to the CBD have asked for immediate assistance in developing indicators of biological diversity and in national reporting, and that the issues and circumstances of each country in meeting this task will be different. For that purpose, a menu of questions, issues and indicators is proposed in Chapter 2. This framework is designed to help Parties choose indicators, based both on their needs and experience, but also in the context of the reporting requirements of the CBD. The flexible menu approach is designed to catalyze and enrich the process of choosing and developing indicators that are appropriate for each country, not to replace that process with a prescribed set of indicators.

To enable it to contribute to and benefit from other assessments, this approach to biodiversity assessment could be combined with Sustainability Assessment that is described in Annex 1. Assessments that share the same system framework strengthen each other and make the best use of assessment capacity (Figure 1.2). For example, a biodiversity assessment could provide biodiversity indicator data to other assessments such as State of Environment Reports, GEO (Global Environmental Outlook) and receive socio-economic indicator data from them.

Characteristics of a user driven Biodiversity Assessment approach

- Set within the broader context of **sustainable development** that gives equal treatment of people and the ecosystem, so that biodiversity is not seen an isolated part of the picture.
- **A hierarchy** of elements/issues and objectives to help select indicators and define performance, so that indicators are kept to a manageable number and tell you something about whether things are getting better or worse.
- **A common framework** of dimensions around which more specific and representative elements can be selected in a comprehensive manner.
- A procedure for developing indicators that can be combined using **performance scales.**
- **An iterative multi-stage cycle**, that can form the long-term basis of monitoring and an action-evaluation cycle.
- Complementary use of **narrative, mapping and measurement** to record the process of engaging stakeholders and their decisions. Often the reasons behind the indicators and choices are the most revealing aspect of the assessment.
- **A user-driven process** where stakeholders determine the issues and indicators that are the most useful to them. This increases the motivation to actually use the results of the assessment and to carry on the monitoring process.

The principles behind 'user driven' assessments encourage stakeholders to assess their assessment needs, and then build a comprehensive vision of sustainability, which is articulated using elements and indicators in an increasingly more specific manner. The method helps ensure that important elements are not missed in the process, and that the measurements are as clear as possible and can be combined to show overall sustainability as well a progress in key dimensions.

A multi stage assessment process

The approach to biodiversity assessment in this Guide recommends the use of a multi stage cycle adapted from the broader sustainability assessment process described in Annex 1. A cycle implies a continuous ongoing process, recognizing that assessments will be done repeatedly to show changes over time, and to support a broad range of decision-making needs.

The stages in the six-cycle of sustainability assessment are easily adapted to biodiversity assessments. The first four stages of the cycle are designed to help users articulate a shared vision of sustainability, that is defined in increasingly more specific ways, using elements, objectives, indicators and performance criteria. The aim of the first four stages is to unpack the components of a broadly defined vision into measurable indicators. The first four stages of the cycle move participants from the general to the specific.

The last two stages help users to assess overall human and ecological wellbeing from the individual indicators, by combining and reviewing. This approach uses performance scales for indicators to help provide a common unit by which indicators can be combined. If indicators are combined, they can be used to show aggregate performance and overall human and ecological wellbeing. All of this information, from individual indicators to aggregated indexes, can be used to aid an assessment of performance and identification of priorities.

The stages are (Figure 2):

1. ***Define the system and goals***. The *system* consists of the people and ecosystem of the area to be assessed. The *goals* encapsulate a vision of sustainable development and provide the basis for deciding what the assessment will measure.
2. ***Identify elements/issues and objectives***. *Elements* are key concerns, issues or features of human society and the ecosystem that must be considered to get an adequate sense of their condition. They are grouped by dimensions.
3. ***Choose indicators and performance criteria***. *Indicators* are measurable and representative aspects of an issue. *Performance criteria* are standards of achievement for each indicator.
4. ***Measure and map the indicators***. Indicator results are recorded in their original measurements, given scores on the basis of the performance criteria, and mapped.
5. ***Combine the indicators and map the indices***. Indicator scores are combined up the hierarchy: indicators into sub-issue indices; sub-issue indices into issue indices; issue indices into dimension indices; and dimension indices into subsystem indices (separate indices for people and the ecosystem). Indices are mapped to reveal visually overall findings and specific patterns of performance.
6. ***Review results and propose policies***. The review links the assessment to action by analysing the patterns and the data behind them to suggest what actions are needed and where. The review also provides the diagnosis for the design of programs and projects.

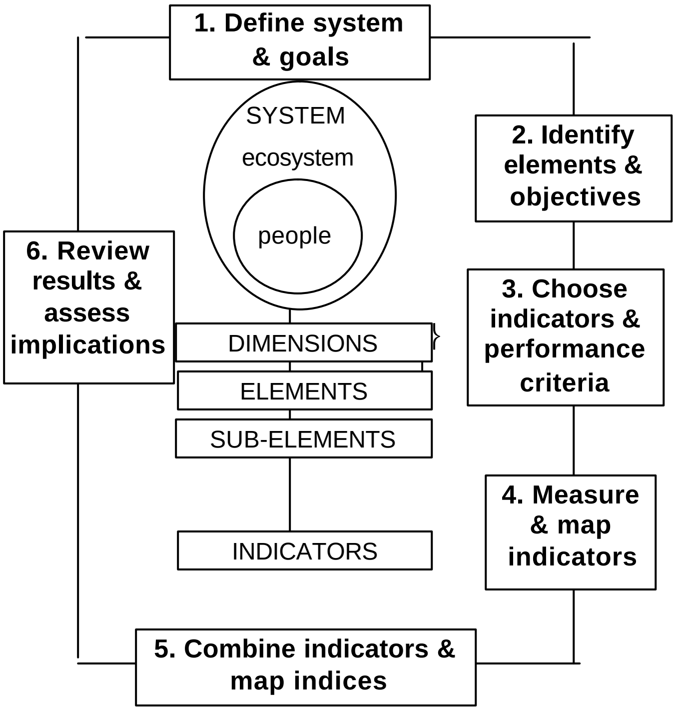

Figure 2. Six-stage assessment cycle (the hierarchy of elements and objectives is in the centre)

Only once the framework of goals, elements/issues and objectives is adopted are indicators chosen to represent the (sub)elements. This helps provide a stronger and more comprehensive framework by which relevant indicators can be chosen.

By comparison, in most other assessment approaches, informal methods like brainstorming and canvassing are used to identify indicators, without going through the first two stages. This usually produces an unwieldy list of indicators, which then has to be reduced to a manageable number. For example, the city of Seattle's 'Sustainable Seattle' assessment started with 150 indicators, which eventually were reduced to 40 (Sustainable Seattle, 1995). If indicators are chosen in a conceptual vacuum, it is very difficult to know how important they are or how relevant to what people want to achieve. Therefore the first stages play a crucial role in this approach to assessment.

This approach is easily adapted to the assessment of biodiversity, while allowing users to place biodiversity in the broader context of sustainable development, and allows users (country governments and other stakeholders) to drive and manage the process accordingly to their needs and capacities.

Chapter 2 of this Guide presents a series of key questions for biodiversity assessment. The questions encompass the issues and indicators that need to be considered when assessing biodiversity and reporting on the CBD. It is not suggested that an assessment use all of the indicators. They are intended as a resource for users to draw on to identify, develop and apply a manageable and cost-effective set of performance indicators for the objectives of the CBD, tailored to their own conditions and priorities. The emphasis is on adaptability, flexibility, and ability to start small and grow as knowledge and capacities develop.

2. A Menu Of Questions, Issues And Indicators For Biodiversity Assessment

A. Introduction

This chapter proposes a set of questions, issues and indicators for assessing biodiversity, national reporting or as part of a larger assessment process that includes a wider range of human and ecological concerns.

This guide proposes that these questions, issues and indicators could be used within the framework of Sustainability Assessment, particularly to assess strategies for biodiversity conservation and sustainable use. Figure 2.1 suggests potential entry points for both CBD reporting within the framework of Sustainability Assessment.

This does not suggest that strategies and Sustainability Assessment are the only entry point for making use of this guide. The examples offered in this section are intended to help catalyze efforts on the part of users to improve their ability to assess and report, rather than limit them. Since countries differ greatly in ecological and socio-economic conditions and in capacities and budgets, it is unlikely that a given country will use all the indicators discussed. Rather, the purpose of the chapter is to provide several options, suitable for a range of conditions and capacities, to assist the selection of a small and cost-effective set of practical performance indicators that are relevant to the objectives of the CBD and to national and local needs.

This section could be used with Annex 2, to develop performance indicators, or with both Annex 1 and 2 to develop a Sustainability Assessment that uses performance indicators in support of assessing human and ecosystem wellbeing together. The choice to use Sustainability Assessment depends entirely on the needs and preferences of the user.

B. WHAT ARE THE STATUS AND TRENDS OF BIODIVERSITY COMPONENTS?

This question responds to the first two parts of Article 7 on identification and monitoring:

> Each Contracting Party shall, as far as possible and as appropriate, in particular for the purposes of Articles 8 to 10 [8: *In situ* conservation. 9: *Ex situ* conservation. 10: Sustainable use of components of biological diversity]:
>
> (a) Identify components of biological diversity important for its conservation and sustainable use having regard to the indicative list of categories set down in Annex 1;
>
> (b) Monitor, through sampling and other techniques, the components of biological diversity identified pursuant to subparagraph (a) above, paying particular attention to those requiring urgent conservation measures and those which offer the greatest potential for sustainable use...

The question is also key to determining how effectively two of the CBD's objectives are being met:

- The conservation of biological diversity.
- The sustainable use of its components.

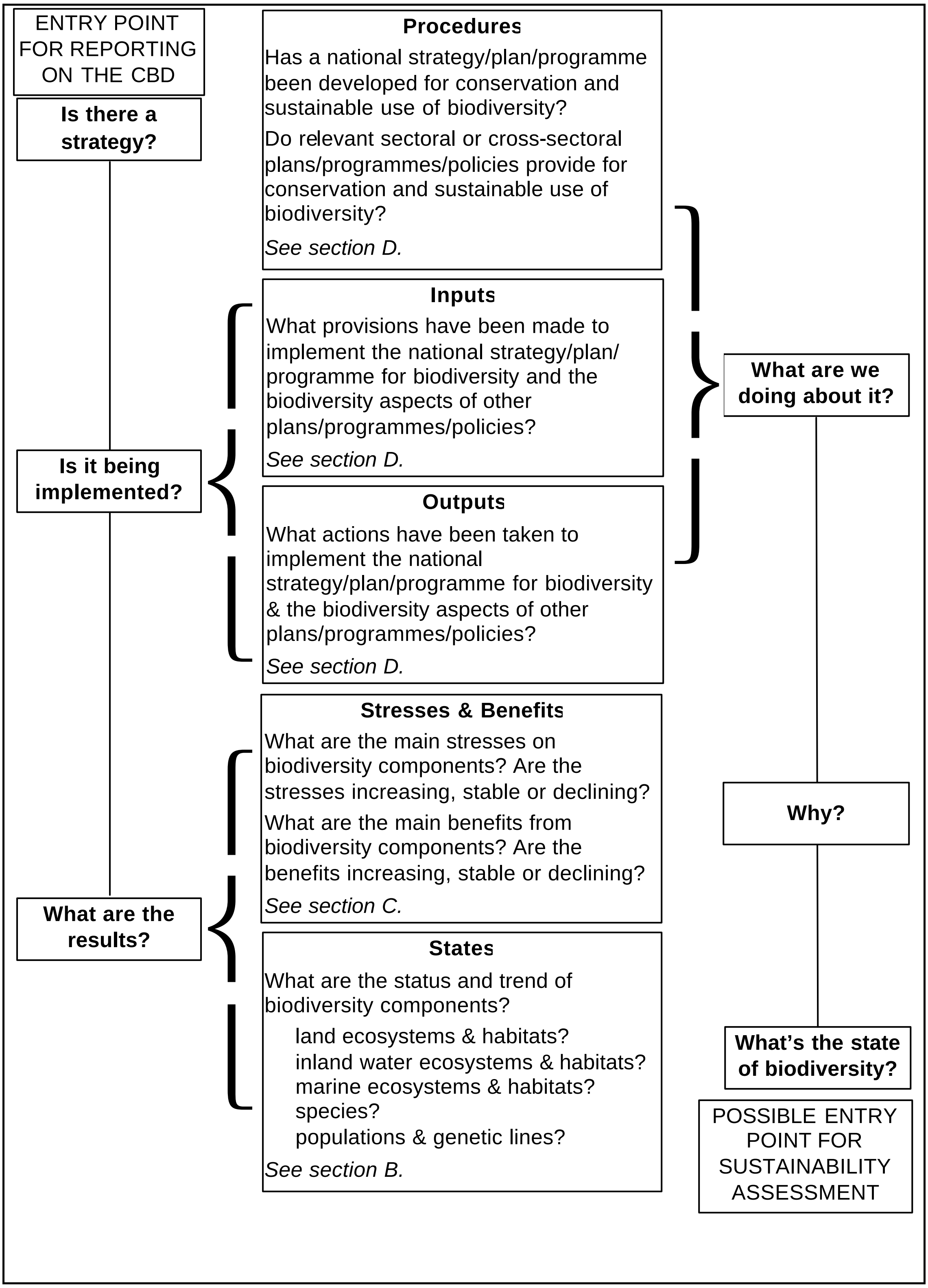

Figure 2.1. Key questions for biodiversity assessment. CBD reporting and system assessment ask the same questions. Only the entry points and sequence differ.

Annex 1 of the CBD lists the following components of biological diversity:

1. Ecosystems and habitats: containing high diversity, large numbers of endemic or threatened species, or wilderness; required by migratory species; of social, economic, cultural or scientific importance; or, which are representative, unique or associated with key evolutionary or other biological processes;
2. Species and communities which are: threatened; wild relatives of domesticated or cultivated species' or medicinal, agricultural or other economic value; or social, scientific or cultural importance; or importance for research into the conservation and sustainable use of biological diversity, such as indicator species; and
3. Described genomes and genes of social, scientific or economic importance.

For asses sment purposes, it could be more practical to rearrange these sets slightly:

Ecosystems and habitats. Ecogeographic or ecospatial diversity. Ecosystems (assemblages of biotic and abiotic components) at all scales, including biomes, bioregions, and communities.

Species. Species, the core and most stable component of biodiversity.

Populations and genetic lines. Intra-specific diversity, covering all levels of organization lower than species, including varieties and breeds, as well as genomes and genes.

The status and trend of these components can be assessed by asking four sets of questions:

B1. What are the status and trend of land ecosystems and habitats?
B2. What are the status and trend of aquatic ecosystems and habitats?
B3. What are the status and trend of species?
B4. What are the status and trend of populations and genetic lines?

B1. WHAT ARE THE STATUS AND TREND OF LAND ECOSYSTEMS AND HABITATS?

The main reasons for assessing diversity above the level of species are (a) because the diversity of ecosystems and habitats is important in itself; and (b) as an indirect way of monitoring species, since it is not practical to monitor directly more than a fraction of species.

Reid *et al.* (1993) have pointed out three problems with assessing ecosystem diversity. First, many different entities and relationships are involved—layers of ecosystems within ecosystems, the pattern (type, size, and distribution) of communities in the landscape, their trophic structure, the pattern of habitats in each community, their species composition, the size and structure of component populations, and the connections and interactions among and within communities.

Second, boundaries between these entities are ambiguous. Ecosystems and habitats are defined subjectively, depending on the objectives of the assessment and the scale at which it is working. Biomes (e.g., tropical rain forests, cold deserts) are not meaningful in a local assessment, just as detailed habitat mapping is not feasible in a national assessment.

Third, communities are transient associations of species. In North America, for example, most plant communities are less than 8,000 years old (Hunter, Jacobson & Webb 1988). There is no point in trying to preserve a specific set of communities, since an important mechanism by which the ecosystem maintains its stability is change.

These considerations suggest that monitoring the fine detail of ecosystem change is unlikely to repay the effort. However, it is desirable to:

- Keep to a minimum the loss and fragmentation of major ecosystems.
- Maintain as much as possible of the structural and functional diversity within major ecosystems.

Loss, fragmentation and structural modification of natural land ecosystems change nutrient and hydrological cycles and the chemistry of the atmosphere, provoke ecological disruptions (such as outbreaks of pests and diseases), and reduce the ability of the ecosystem to recover from disturbances. The amount and pattern of natural and semi-natural areas are also critical for maintaining species diversity (Levin 1995; O'Neill *et al.* 1995).

B1.1. What is the original/potential area of the major land ecosystems and habitats?

The starting point is a classification and map of major ecosystems or habitats of the land. What qualifies as a major ecosystem or habitat depends on the size of the spatial level concerned (the area being assessed) and the resources available for the assessment.

Table 2.1 shows how large an area would be covered by a map unit of 1 mm^2, 1 cm^2, or 1 m^2, at different map scales. For example, Sri Lanka's total area of 6 561 000 ha could be covered on a single 1 m^2 sheet at a scale of 1:300 000. If it were, the smallest map unit (a 1 mm^2 dot) would represent 9 hectares.

Map scale	**Area (ha) covered by 1 mm^2 of map**	**Area (ha) covered by 1 cm^2 of map**	**Area (ha) covered by 1 m^2 of map**
1:50 000	0.25	25	250 000
1:100 000	1	100	1 000 000
1:200 000	4	400	4 000 000
1:300 000	9	900	9 000 000
1:400 000	16	1 600	16 000 000
1:500 000	25	2 500	25 000 000
1:600 000	36	3 600	36 000 000
1:700 000	49	4 900	49 000 000
1:800 000	64	6 400	64 000 000
1:900 000	81	8 100	81 000 000
1:1 000 000	100	10 000	100 000 000

Table 2.1. Area (in hectares) covered by three sizes of map unit, depending on map scale.

The example of a 1 m^2 sheet is arbitrary (it could be bigger or smaller) and of course Sri Lanka could be mapped on more sheets at larger scales. However, it serves to illustrate that if very large areas are being assessed, scales will probably be small and therefore the smallest map unit will be relatively large. This means that the smallest ecosystem that can be distinguished will also be relatively large. These scale considerations will strongly influence the degree of differentiation required of a classification of ecosystems and habitats.

Ecosystem classifications need to be:

- 'Mappable' at a convenient scale and observable using the most feasible means of monitoring.
- Ecologically meaningful, using entities that are useful for ecological analysis and biodiversity management.
- Linked to decision-making, showing boundaries of jurisdictions as well as ecosystems.
- Able to integrate land, inland waters, and sea, by showing inland drainage basins and divisions of the coastal zone (coastal plain, tidelands, and marine components [Ray & Hayden 1992]).

Available classifications that are mapped may be based on ecoregions, vegetation, floristics, zoogeography, biogeoclimatology, or physical factors—whatever exists is a good starting point, as long as it meets the first criterion above. The classification can be improved over time to meet the second criterion. The last two criteria can be met by adding a jurisdictional layer and a basin and coastal zone layer (see also section B2).

Because forests are a special theme of the CBD, it is useful to distinguish forest and non-forest ecosystems/habitats when assessing this and the other questions on the status and trends of land ecosystems and habitats.

Tables 2.2 and 2.3 show different classifications for Cuba and Nepal respectively, to illustrate some of the options. In the case of Cuba, forest types provide the most detailed classification but cover only that part of the country remaining under forest (about a third of the land area). In the case of Nepal, habitats provide the most detailed classification and cover the entire country. Ecosystems and habitats may be defined on the basis of existing vegetation (as altered by people) potential vegetation (expected vegetation in the absence of human alteration), or original vegetation (presumed vegetation before human alteration). The latter two (potential or original) are more informative because they allow determination of how much of each ecosystem has been lost and fragmented to date. Thus MacKinnon (1997) records an estimate of the original extent of each habitat as well as an estimate of the current extent.

Ecoregions (km^2)		**Major ecofloristic zones (km^2)**		**Forest types (km^2)**	
Cuban moist forests	20069	Lowland very moist	6728	Mangrove	7665
Cuban dry forests	61466	Lowland moist with long dry season	79554	Freshwater swamp forest	3616
Cuban pine forests	6017	Lowland sub-dry	154	Upper montane forest	83
Cuban wetlands	5345	Premontane moist	18736	Lower montane forest	3146
Cuban cactus scrub	3044	Premontane dry	3850	Lowland evergreen broadleaf rain forest	581
				Semi-evergreen broadleaf forest	1252
				Deciduous/semi-deciduous broadleaf	5306

				forest	
				Thorn forest	819
				Needleleaf forest	2719
				Sclerophyllous dry forest	92
				Disturbed natural forest	6711
				Exotic species plantations	973
Total land	95941	Total land	109022	Total forest	32963

Table 2.2. Ecosystem/habitat classifications for Cuba. Ecoregions (Dinerstein *et al.* 1995). Major ecofloristic zones (Murray *et al.* 1997). Forest types (Iremonger, Ravilious, & Quinton 1997). Note: total areas differ, and ecosystems/habitats on the same line to do not correspond to each other. Note also that ecoregions and ecofloristic zones record *potential* vegetation, but forest types record *existing* vegetation.

Habitats (km^2)		Ecofloristic zones (km^2)		Forest types (km^2)	
Alpine	13426	Lowland semi- & sal evergreen forest	19923	Semi-evergreen moist broadleaf forest T	113
Birch forest	1932	Montane temperate & sub-alpine forest	7989	Deciduous/semi-deciduous broadleaf forest T	11509
Blue pine	1567	Western Himalayan moist temperate forest	642	Deciduous broadleaf forest N	8197
Cleared	43849	Himalayan moist temperate & sub-alpine forest	12401	Evergreen needleleaf forest N	18408
Dry deciduous	481	Dry deciduous forest	1359	Disturbed natural forest N	36421
Degraded forest	36418	Deciduous forest	25375	Total forest	74648
Glaciers	15434	Lower montane, sub-tropical & evergreen hill forest	5333		
Moist temperate	2707	Montane & temperate mixed forest	14895		
Montane wet temperate	1596	Sub-tropical pine forest	11451		
Subalpine conifer	5533	Sub-tropical pine & Himalayan temperate forest	5785		
Sub-tropical hill forest	3077	Alpine scrub	7692		
Semi-evergreen	113	Alpine steppe, dwarf juniper scrub	34535		
Sub-tropical pine	9711				
Tropical moist deciduous	11509				
Total land	147353	Total land	147380		

Table 2.3. Ecosystem/habitat classifications for Nepal. Habitats (MacKinnon 1997). Ecofloristic zones (Murray *et al.* 1997). Forest types (Iremonger, Ravilious, & Quinton 1997). In the forest types column, T = tropical type, N = non-tropical type. Note: total areas differ, and ecosystems/habitats on the same line to do not correspond to each other. Note also that

ecofloristic zones record *potential* vegetation, but habitats and forest types record *existing* vegetation.

B1.2. What is the current area of the major land ecosystems/habitats? What percentage of each is (a) unconverted, (b) converted to cultivation (cropland, pasture, or plantations), or (c) converted to settlements, infrastructure or other human structures?

This indicator shows how much of each ecosystem has been lost and how much remains (although what remains may not be intact). Over time, it will show whether ecosystems continue to be lost and (if so) which ones and to what extent. The indicator can be measured as the number of pixels (the smallest map units) that are (a) unconverted, the number that are (b) converted to cultivation, and the number that are (c) converted to buildings and other structures. It is usually easy to distinguish between an unconverted and a converted ecosystem (whereas distinguishing between natural and modified forms of an unconverted ecosystem may be difficult—see below).

Variants of this indicator:

a. If land ecosystems have not been mapped, it is still useful to record how much of the land area as a whole is (a) unconverted, (b) converted to cultivation, (c) converted to structures.
b. Percentages of a particular ecosystem type—such as forests or wetlands—that are (a) unconverted, (b) converted to cultivation (cropland, pasture, or plantations), or (c) converted to settlements, infrastructure or other human structures. This allows assessment of loss of ecosystem types that are considered a priority, without waiting for a systematic classification of ecosystems or for all major ecosystems to be mapped. A further simplification is to record the proportions of the ecosystem type that are (a) unconverted or (b) converted, without distinguishing the kind of conversion.
c. Percentage of area dominated structurally by nondomesticated species, and rate of change from structural dominance of nondomesticated species to domesticated species. An ecosystem that is dominated structurally by nondomesticated species is the same as (and a way of defining) an unconverted ecosystem. The indicator ignores the kind of conversion (whether to cultivation or to structures).

B1.3. What is the degree of fragmentation of the unconverted portion of each land ecosystem?

This indicator shows to what extent unconverted ecosystems have been split into separate patches or blocks, how large the blocks are, and how far apart. It can be measured by the number of blocks of pixels, the size of the blocks, and the distances between blocks.

Variants of this indicator:

a. Degree of fragmentation of the unconverted portion of a particular ecosystem type, such as forests or wetlands.
b. Percentage of area dominated by nondomesticated species occurring in patches greater than 1 000 km^2. Since the minimum desirable patch

size is likely to vary from ecosystem to ecosystem, it is probably better specified as part of the performance criteria for the indicator.

B1.4. What percentage of each land ecosystem (unconverted portion) is (a) natural, (b) modified?

This indicator shows how much of each unconverted ecosystem remains intact. *Natural* here means negligibly to lightly human-influenced. *Modified* means moderately to heavily human-influenced but not converted. The essential difference between a natural ecosystem and a modified ecosystem is that it is highly probable that community diversity is *not* being lost within a natural ecosystem and *is* being lost within a modified ecosystem. An area that has been lightly logged, hunted or fished could be considered a natural ecosystem if its structure is basically the same as an equivalent area where these activities are not taking place. Thus a self-regenerating forest without roads that is not used for livestock production and from which only a few trees are removed for timber could be assumed to be natural. So could second-growth forest if it now meets these criteria and has recovered the species composition and structural attributes of old-growth forest on a similar site. A clearcut forest that is not planted but regenerates naturally can be assumed to be modified. A limitation of this indicator is that “natural” and “modified” need to be defined for each ecosystem type, and differences between the two may not be readily observable.

A possible variant of this indicator:

a. Percentage of each unconverted ecosystem with a high frequency of introduced (non-native) species. This uses the presence of non-native species as a measure of modification. A “high frequency” of non-native species needs to be defined. The indicator can be measured as the number of pixels with no or few introduced species (= natural) versus the number with many introduced species (= modified). Few/many may be an absolute number (less hard to determine) or in relation to the number of native species in the same group, such as class or phylum (more hard to determine).

B1.5. What are the status and trend of ecological communities within each land ecosystem (communities at risk as a percentage of all communities in that ecosystem)?

This indicator shows how much of each unconverted ecosystem is threatened, as well as the status of communities within the ecosystem. For example, in British Columbia (Canada), 14 biogeoclimatic zones (major land ecosystems) are recognized. Plant communities have been described within each biogeoclimatic zone (from one community in the Spruce-Willow-Birch zone to 79 communities in the Coastal Western Hemlock zone). The communities are monitored and their status defined as endangered, vulnerable, or not at risk (BC Conservation Data Centre pers. comm.).

This indicator also allows for monitoring of communities and habitats that might not be captured by reviews of major ecosystems.

B2. WHAT ARE THE STATUS AND TREND OF AQUATIC ECOSYSTEMS AND HABITATS?

Conversion of coastal areas to cultivated or built land often destroys wetlands and other habitats, including the nursery areas of fisheries. Structures to protect shores can accelerate their destruction by preventing the natural replenishment of beaches. Dams and dikes can harm species, habitats, fisheries—and people—by drowning some areas, denying water to others, changing the timing and volume of flow, increasing the salinity of coastal waters, trapping sediments, and starving downstream wetlands of nutrients and silt (Pernetta & Elder 1993; Welcomme 1985).

The following questions need to be considered separately for marine and inland waters. However, they are taken together here to avoid repetition.

B2.1. What is the original/potential area of the major aquatic ecosystems and habitats?

Aquatic ecosystems may be defined hydrologically, physiographically, or zoogeographically (e.g., based on the occurrence of fishes or molluscs).

B2.2. What is the current area of the major aquatic ecosystems/habitats? What percentage of each is (a) unconverted, (b) converted to human structures?

The distinction between conversion to cultivation and conversion to structures does not apply to aquatic ecosystems since aquaculture requires structures of some kind. Conversion to human structures is defined here as dominated or strongly influenced by dams, dikes, embankments, jetties, quays, breakwaters, aquaculture pens, etc.

One option is a linear measure: the percentage of the shoreline of a marine or inland water ecosystem that is dominated or strongly influenced by human structures ("strongly influenced" will need to be defined). Another option—suitable for rivers—is a flow measure: for example, flow affected by dams as a percentage of total flow.

A more limited but more easily determined flow measure is: flow dammed for hydropower as a percentage of dammable flow. The maximum river flow that is dammable for hydropower (gross theoretical capability) is measured as the annual energy potentially available in a country if all natural flows were harnessed with 100% efficiency by turbines down to sea level or to the water level at the border with neighbouring countries. The figure is usually estimated on the basis of precipitation and run-off. How much of the flow has been or is about to be dammed is indicated by hydropower in operation and under construction. This is measured by the electrical energy per year actually generated (in operation) and that will probably be generated (under construction).

B2.3. What is the degree of fragmentation of the unconverted portion of each aquatic ecosystem?

This indicator serves the same purpose as its equivalent for the land but may be harder to apply. It is most relevant when aquatic ecosystems are split up by barriers such as dams. For example, dams have profoundly altered the

Middle Zambezi basin, effectively turning it into a human-dominated ecosystem even though settlements are sparse (Timberlake 1998).

B2.4. What percentage of each aquatic ecosystem (unconverted portion) is (a) natural, (b) modified?

One measure of naturalness/modification of inland waters and estuaries is the "index of biotic integrity". This indicator combines measures of species richness and composition, trophic structure, and fish abundance and condition, to assess the structural and functional integrity of aquatic ecosystems. It has proven suitable in all regions of the USA (where it was developed), and in estuaries as well as streams, although more difficult to apply in regions of low species richness. Measures of species richness and composition include total number of fish species and the number and identity of species in particular groups. Measures of trophic structure include the proportions of individuals as omnivores (having adult diets of ≥ 25% plant material and ≥ 25% animal material), insectivores, or top carnivores (having adult diets predominantly of aquatic vertebrates or crayfish). Measures of fish abundance and condition include the number of individuals in a sample, the proportion of individuals as hybrids, and the proportion of individuals with disease, tumors, fin damage or skeletal anomalies (Miller *et al.* 1988).

The two main forms of modification of aquatic ecosystems are pollution and fisheries, both of which are covered in section C1 on stresses.

B2.5. What are the status and trend of ecological communities within each aquatic ecosystem (communities at risk as a percentage of all communities in that ecosystem)?

This indicator can show how much of each unconverted ecosystem is threatened, and the status of particular communities within the ecosystem. The latter is the more likely use, if knowledge of marine and inland water ecosystems is limited. An example is assessment of the status of coral reefs, including the percentage of reef area considered to be at low, medium, and high risk (Bryant *et al.* 1998).

B3. WHAT ARE THE STATUS AND TREND OF SPECIES?

The rising numbers of plant, animal and other species threatened with extinction represent an irreparable loss. Species have intrinsic worth. They are also the source of all biological wealth—supplying food, raw materials, medicines, recreational resources, and a store of other goods and services worth many billions of dollars per year. Although it is natural for species to come and go, the background (or natural) rate of extinction is extremely low: less than 0.01% per century. Globally the current rate of extinction among birds and mammals is perhaps 100 to 1 000 times the natural rate (Reid & Miller 1989).

B3.1. What percentage of species is threatened with (a) extinction, (b) extirpation?

This indicator—threatened species in a group as a percentage of total species in that group—shows the number of species known or believed to be at risk of extinction (global loss of the species) or extirpation (loss of the species from the area being assessed but not globally). Assessment of risk of extinction requires global collaboration, except in the case of species that are endemic to the area in question. Assessment of risk of extirpation can be done independently. If possible, it is useful to cover both, but to clearly distinguish them. For species that have been evaluated and for which there are adequate data, IUCN defines two categories of extinction (extinct, and extinct in the wild), and six categories of risk in two groups. *Threatened* includes critically endangered, endangered, and vulnerable. *Lower risk* includes conservation dependent, near threatened, and least concern (IUCN 1994).

The percentage of threatened species is a better indicator of maintenance of species diversity than the number of threatened species. This is because the number reflects not only threats to species but also the total number of species. (A country with 10 threatened species out of a total of 1,000 species is obviously performing better than a country with 10 threatened species out of a total of 100.) Since the total number of species is not known and probably unknowable, the indicator focuses on groups whose numbers have been estimated and whose status is monitored. The starting point is to select at least one group that is high up the taxonomic hierarchy (phylum/division, or subphylum/subdivision, or class), that is reasonably numerous (e.g., not the class Ginkgoopsida with only one species!), and that monitoring could cover completely or virtually completely (that is, all native species could be identified and listed and the status of almost all of them [90%?] could be monitored). Complete coverage may not have been attained yet but it is a practical possibility. As monitoring capacities improve, other groups can be added. For example, a country might start with birds, then add other higher animal classes (mammals, reptiles, amphibians, bony fishes, cartilaginous fishes) and higher plant subdivisions and classes (e.g., flowering plants, gymnosperms, ferns), and perhaps one or two classes in other phyla (e.g., bivalve molluscs). This approach is practical and enables the indicator to use different taxonomic weights. Just as the loss of a species is more significant than the loss of a population because it represents a more distinct and less replaceable package of genes, so losses higher up the taxonomic hierarchy are of even greater concern than the loss of a species. Hence it is important to consider higher groups and determine the proportion of each group that consists of threatened species.

B3.2. What are the status and trend of specified indicator species (or species groups)?

This indicator measures changes in the status of designated indicator species (or groups of species), such as increases or declines in numbers, changes in population structure or size classes, and changes in migration and other behaviour. Monitoring at this level of detail is expensive, and usually can be extended only to those species whose status is believed to be particularly informative. Desirable features of potential indicator groups are (Groombridge & Jenkins 1996):

- Taxonomically well known so that populations can be reliably identified and named.
- Biologically well understood.
- Easy to survey (e.g., abundant, non-cryptic).

- Widely distributed at higher taxonomic levels (e.g., order, family, genus) across a large geographic and habitat range.
- Diverse and including many specialist taxa at lower taxonomic levels (species and subspecies) that would be sensitive to habitat change.
- Representative (as far as is known) of distribution and abundance patterns in other related and unrelated taxa.
- Actually or potentially of economic importance.

B4. WHAT ARE THE STATUS AND TREND OF POPULATIONS AND GENETIC LINES?

Extinctions of populations are early warnings of threats to species. The loss of a genetic variant matters less than the loss of a species, except for:

- Wild species that are culturally, economically or ecologically important and whose geographical populations vary greatly.
- Domesticated species.

The genetic stocks within crop varieties, livestock breeds, the wild relatives of crops and livestock, and domesticated strains of micro-organisms, provide essential traits for increasing and improving agricultural production and the development of biotechnologies. The traits include disease resistance, hardiness, productivity, marketability, and culturally desirable qualities such as flavour, and are constantly being sought to cope with changing markets and environmental conditions.

Losses of populations and genetic variants are inevitable, and are bound to be at higher rates than losses of species. Moreover, monitoring at that level is much more difficult and expensive than monitoring species. Implementing one of the following indicators—especially either or both of the first two—for one species would be a good start.

B4.1. What percentage of the populations of a particular wild species are at risk of extinction?

This indicator is intended to provide a broad measure of how well major genetic stocks are being maintained within selected wild species that meet the criteria of “cultural, economic or ecological importance” and “high variability among geographical populations”. Pines and salmon are examples of such species. For example, in the Pacific region of Canada the status has been assessed of 9,663 populations of five species of salmon and two andronomus trout species. A population was defined as a locally adapted spawning population (or sometimes a group of such populations) known to originate from a well-defined location in either a small stream or limited section of a large river or lake. The populations were classified as extinct, at risk of extinction (high risk, moderate risk, special concern), not at risk, or unknown (Slaney *et al.* 1996). The indicator requires substantial scientific and technical resources and is likely to be justified only if the species is considered to be particularly important (as salmon and trout are in western North America).

B4.2. What percentage of the varieties or breeds of a particular crop or livestock species are threatened?

This indicator—threatened varieties/breeds of a crop or livestock species as a percentage of total varieties/breeds of that species—shows the proportion of genetic variants in a selected domesticated species that is at risk of extinction or extirpation. For any particular species, it requires an inventory of varieties (or breeds) that exist on farms and in *ex situ* and *in situ* genebanks, and determination of the status of each variety (or breed). A common complication is that entities with the same name may be different, whereas entities with different names may be the same. Genetic analysis is necessary to identify distinct entities and sort out synonyms. Another issue is the existence of research lines, hobby breeds, and new varieties that are not yet established (and may never be). Some people believe that all genetic variation is worth preserving, so this issue does not matter. Others think that the issue is a problem because experimental and fancy varieties/breeds distort the indicator by inflating both the number of threatened entities (because many of them are necessarily temporary) and the total number of entities. Both schools of thought can be accommodated by distinguishing (a) varieties/breeds used for agricultural purposes for a defined minimum duration (say 50 years), and (b) other varieties/breeds. It is also necessary to distinguish varieties/breeds that are threatened with global extinction and those that are threatened with extirpation from the area being assessed (but not globally).

B4.3. What is the turnover rate of varieties and breeds?

This can be measured by the varieties or breeds of selected crops or livestock grown today as a percentage of the number grown 25 years ago. However, the indicator is hard to interpret because both the maintenance of traditional varieties and breeds (little change) and adaptation to new conditions through the adoption of new varieties and breeds (much change) are positive signs. A simpler (but just as limited) form of this indicator is the number of crop or livestock species grown in an area as a percentage of the number grown 25 years ago.

B4.4. How genetically diverse or uniform is agricultural production?

This can be measured by any of the following:

a. Numbers of varieties or breeds making up 90% (or 80%) of production of selected crops or livestock. This indicator shows very roughly how much genetic diversity is currently being maintained in the field. Production can be defined as quantity of product, area under cultivation (crops), or numbers of head (livestock).
b. Numbers of varieties or breeds accounting for at least 2% (or at least 5%) of production of selected crops or livestock. Both this and the previous indicator can be weighted so that, for example, two varieties each accounting for 50% of production would score better than one accounting for 98% and the other for 2%.
c. Coefficient of kinship or parentage of selected crops or livestock. This is the most informative of these indicators but is technically more demanding. A high

coefficient would be obtained if one variety/breed were extremely common, or if all varieties/breeds shared a similar lineage (Reid *et al.* 1993).

C. WHAT ARE THE STRESSES ON BIODIVERSITY COMPONENTS AND WHAT ARE THE BENEFITS FROM THEM?

This question responds to the third part of Article 7 on identification and monitoring:

> Each Contracting Party shall, as far as possible and as appropriate, in particular for the purposes of Articles 8 to 10 [8: *In situ* conservation. 9: *Ex situ* conservation. 10: Sustainable use of components of biological diversity]:
>
> (c) Identify processes and categories of activities which have or are likely to have significant adverse impacts on the conservation and sustainable use of biological diversity, and monitor their effects through sampling and other techniques...

The question is also key to determining how effectively all three of the CBD's objectives are being met:

- The conservation of biological diversity.
- The sustainable use of its components.
- The fair and equitable sharing of the benefits arising out of the utilization of genetic resources.

Stresses and benefits can be assessed by asking five sets of questions:

C1. What are the main stresses on biodiversity components? Are the stresses increasing, stable or declining?
C2. What are the main benefits from biodiversity components? Are the benefits, increasing, stable or declining?
C3. How much benefit is obtained per unit of stress?
C4. What are the main social and economic factors behind the stresses?
C5. Who gets the benefits from biodiversity components and how are they shared?

C1. WHAT ARE THE MAIN STRESSES ON BIODIVERSITY COMPONENTS? ARE THE STRESSES INCREASING, STABLE OR DECLINING?

The first step is to identify, and describe qualitatively, the chief human stresses on biodiversity. Gradually, the stresses can be quantified with progressively greater accuracy and detail. Biodiversity management will be aided if the threats are quantified by biodiversity component (the ecosystem, species or other component that is affected by the stress) and by sector (the economic sector or activity that is the source of the stress, such as agriculture, a specific industry, or subsistence hunting). This would improve monitoring and understanding of the impacts of particular threats on the status of components, and the contributions of particular sectors to those threats.

Quantification requires the adoption and consistent use of classifications of biodiversity components, stresses, and economic sectors. Ecosystem classifications have been discussed (section B1), species are already classified taxonomically, and economic sectors are classified in the *International standard industrial classification of all economic activities* (ISIC)

(United Nations 1990) and its national equivalents. The ISIC does not include subsistence activities, but these can be added either by assigning them to "households" (not very informative) or by making them subdivisions of the standard resource production sectors (much more informative). In the latter case, for example, subsistence harvesting of wood (for fuel and timber) would be included as a subdivision of forestry. A classification of human stresses on biodiversity is proposed in Table 2.4, which also lists the sectors likely to be sources of particular stresses.

With the help of such classifications it is possible to quantify stresses along the lines of the example in Table 2.5. Many biodiversity components are subject to several human stresses as well as to natural factors, and it is often hard to tell the relative importance of each. Nonetheless, rough estimates can be made as a start, and revised over time as knowledge improves.

Component	Stress	Sector
Directly affected ecosystem, Community, Species, or subspecific Taxonomy	Habitat destruction due to ecosystem conversion (including soil degradation of converted ecosystems)	Agriculture, Silviculture, Aquaculture, Mineral extraction, Construction, Energy supply, Water supply, Transport
	Habitat destruction due to modification of unconverted ecosystems (e.g, browsing or grazing by livestock, logging, damage to reefs or sea bottom by fishing, grassland burning for wildlife production, reduced water levels due to water abstraction)	Agriculture, Forestry, Fishing, Hunting & trapping, Plant gathering, Water supply
	Stock depletion (resource): reductions in the size of target stocks & populations (e.g., overharvesting of trees by logging, of fish by fishing, & of animals by hunting & trapping)	Forestry, Fishing, Hunting & trapping, Plant gathering
	Stock depletion (non-resource): reductions in the size of non-target stocks & populations (e.g., incidental take by fishing, shooting [but not poisoning] of predators by farmers, disturbance by people & livestock)	Agriculture, Forestry, Fishing, Hunting & trapping
	Pollution and poisoning: accidental or deliberate emissions to land, water, or air, including use of pesticides & poisons	Agriculture, Forestry, Silviculture, Mineral extraction, Construction, Energy supply, Transport, Manufacture, Wholesale & retail trade, Services, Government, Households
	Translocation of species: competition, predation, parasitism or infection by introduced (non-native) species, including feral but excluding domesticated species	Agriculture, Silviculture, Fishing, Aquaculture

Table 2.4. Classification of human stresses on biodiversity and of sectors likely to be sources of particular stresses. Biodiversity components directly affected by a particular stress need to be specified.

Component	%	Stress	%	Sector
Ponderosa Pine ecosystem: 30 plant communities: 10 not at risk + 20 (67%) at risk (11 vulnerable + 9 endangered)	70	habitat destruction due to conversion	40	agriculture
			30	construction & transport (settlement & roads)
	20	habitat destruction due to modification	20	forestry (logging)
	10	introduced species	9	agriculture
			1	other

Table 2.5. Illustrative account of human stresses on community diversity of the Ponderosa Pine ecosystem (biogeoclimatic zone), British Columbia, allocating stresses by type and by source sector (Prescott-Allen 1997).

This procedure will enable answers to be developed to the following questions:

C1.1. What are the main human stresses on each land ecosystem or habitat assessed under question B1, and how much does each sector/human activity contribute to them?

Using the classification of stresses in Table 2.4 (or some other classification) estimate the percentage contribution of each stress to the status and trend of the ecosystem/habitat concerned. Then—taking each ecosystem/habitat in turn—estimate the percentage contribution of each sector to the stress concerned (along the lines of the example in Table 2.5).

C1.2. What are the main human stresses on each aquatic ecosystem or habitat assessed under question B2, and how much does each sector/human activity contribute to them?

Using the classification of stresses in Table 2.4 (or some other classification) estimate the percentage contribution of each stress to the status and trend of the ecosystem/habitat concerned. Then—taking each ecosystem/habitat in turn—estimate the percentage contribution of each sector to the stress concerned (along the lines of the example in Table 2.5).

C1.3. What are the main human stresses on each species assessed as threatened or declining under question B3, and how much does each sector/human activity contribute to them?

Using the classification of stresses in Table 2.4 (or some other classification) estimate the percentage contribution of each stress to the status and trend of the species concerned. Then—taking each species in turn—estimate the percentage contribution of each sector to the stress concerned (along the lines of the example in Table 2.5).

C1.4. What are the main human stresses on each set of populations, varieties or breeds assessed as threatened or declining under question B4, and how much does each sector/human activity contribute to them?

Using the classification of stresses in Table 2.4 (or some other classification) estimate the percentage contribution of each stress to the status and trend of the populations/varieties/breeds concerned. Then—taking each set of populations/varieties/breeds in turn—estimate the percentage contribution of each sector to the stress concerned (along the lines of the example in Table 2.5).

C1.5. What is the total stress on biodiversity due to (a) habitat destruction due to ecosystem conversion, (b) habitat destruction due to modification of unconverted ecosystems, (c) stock depletion, (d) pollution and poisoning, (e) translocation of species?

These are summed from the results of questions C1.1 through C1.4, and could be recorded as hectares affected per year, percentage of total area affected per year, numbers of communities or species affected, or percentage of communities or species affected.

C.1.6. What is the total stress on biodiversity due to each of the main economic sectors or human activities?

These are summed from the results of questions C1.1 through C1.4, and could be recorded as hectares affected per year, percentage of total area affected per year, numbers of communities or species affected, percentage of communities or species affected, or percentage contribution to each type of stress.

The biodiversity assessment may also address (or other assessments will address) the impacts of human activities on ecosystem quality and hence on biodiversity. The following questions address these concerns.

C1.7. What is the extent and degree of soil degradation?

Extent and severity of soil degradation due to erosion, loss of nutrients and organic matter, salinization, pollution, and physical deterioration (such as compaction). Total land area affected $\times$ severity classes (light, moderate, severe, extreme) as a percentage of cultivated land area + modified land area (grazing land + forests subject to logging).

C1.8. What is the rate of timber extraction from forests?

Fellings/cutting as a percentage of net annual increment. If data on fellings/cutting are not available, data on removals (i.e., excluding material left *in situ*) are a possible substitute. If data on net annual increment are not available, volume data are a possible substitute but are harder to interpret. (Change in forest area due to conversion is covered in section B1.)

C1.9. What is the extent and degree of water pollution?

Oxygen balance, nutrient levels, acidification, and levels of coliforms, suspended solids, heavy metals and other pollutants in inland and marine waters.

C1.10. What is the rate of water extraction?

Water withdrawals as percentage of supply.

C.1.11. How much pressure is on fisheries?

Depleted (overfished), declining, and recovering stocks as a percentage of total stocks. If this indicator is unavailable or incomplete (some, not all, stocks covered), additional indicators are: catch per unit of catching capacity; and catching capacity per unit of continental shelf area or fishing area.

C.1.12 How much harvesting pressure is on land animals and plants?

Depleted (overharvested), declining, and recovering mammal/bird/reptile/amphibian/plant/other stocks as a percentage of total mammal/bird/reptile/amphibian/plant/other stocks.

C.1.13 What is the likelihood of a specific biodiversity component being lost and the probable magnitude of that loss?

This is a risk index, combining a measure of an ecosystem's or species' sensitivity to stress and a measure of actual stress on the ecosystem or species concerned. Measures of ecosystem sensitivity include soil type, climate, slope, and the extent so far of conversion and modification; and measures of stress are the current rates of conversion, modification, and other stresses (Hammond *et al.* 1995). In one example of a species risk index, the measure of sensitivity is the number of endemic species (per unit area) in a community, and the measure of stress is the percentage of the community that has been lost (Reid *et al.* 1993).

C2. WHAT ARE THE MAIN BENEFITS FROM BIODIVERSITY COMPONENTS? ARE THE BENEFITS, INCREASING, STABLE OR DECLINING?

The CBD objective on benefits refers to the benefits from using genetic resources. These benefits are increased yields and new, better quality or more marketable products from agriculture, silviculture, aquaculture, and chemical manufacture (pharmaceuticals, etc.) through use of germplasm with or without advanced biotechnologies. Of course, the benefits of biodiversity are much broader than genetic resources, including extracted resources from domesticated and wild species, on site resources, species services, ecosystem services, and non-use values (Table 2.6).

The benefits from biodiversity are hard to measure and each type requires somewhat different modes of measurement. The first step is to identify, and describe qualitatively, the chief benefits from biodiversity. Gradually, they can be quantified with progressively greater accuracy and detail. Monitoring and understanding of the contributions of particular components to the flow of benefits and the distribution of benefits among sectors will improve if the benefits are quantified by biodiversity component (the ecosystem, species or other component that provides the benefit) and by sector (the economic sector or activity that obtains the benefit).

Table 2.6 lists possible measures of benefits. The aim is to measure the benefits obtained by the sectors concerned, using methods that are widely understood and accepted. Dubious or controversial measures (such as contingent valuation) have been excluded. In the case of tourism services, income is used rather than (e.g.) travel cost, because it better reflects the benefits to the sector (hotels, restaurants, tour guides, etc.) on site.

Type of benefit	Sector	Measure of benefit
Extracted resources (controlled): resources obtained from domesticated species, converted ecosystems, or both (organisms killed or removed alive for food, timber, fuel, medicine, other)	Agriculture, Silviculture, Aquaculture	Increased yield/improved product/increased income
Extracted resources (uncontrolled): resources obtained from wild species and unconverted ecosystems (organisms killed or removed alive for food, timber, fuel, medicine, other)	Forestry, Fishing, Hunting & trapping, Plant gathering	Increased yield/improved product/increased income
On site resources: species & ecosystems that people pay to use *in situ* without killing the resource or removing it from the site	Tourism services	Increased income
Genetic resources: germplasm from domesticated or wild taxa	Agriculture, Silviculture, Aquaculture, Chemical manufacture	Increased yield/improved product/increased income
Species services: services of domesticated or wild species, such as pollination & pest control	Agriculture, Silviculture	Increased yield/improved product/increased income
Ecosystem services: services of ecosystems, such as energy storage & transfer, nutrient cycling, maintenance of chemical balance, climate moderation, flood control, coastal protection, & soil renewal	All sectors & society at large	None or replacement cost (rarely, since life-support services are irreplaceable)
Non-use values: valuing the existence of species & ecosystems for themselves or in support of spiritual or intangible values	Non-sector groups & individuals	None

Table 2.6. Classification of benefits from biodiversity, sectors likely to obtain the benefits, and measures of the benefits.

Component	Benefit	Sector
Wild & semi-wild upper Amazon clones of *Theobroma cacao* (Iquitos, Nanay, Parinari & Scavina populations) from the Varzea forests ecoregion, Peru	Genetic resource: used in the development of hybrid cultivars (grown in West Africa, Malaysia, Brazil, & probably elsewhere [production & % of total cacao production to be specified]), to which they have contributed heterosis (hybrid vigour), fast growth rate, high yields, early fruiting, & drought tolerance, providing an average yield increase of 70%	Agriculture

Table 2.7. Illustrative account of benefits from Peruvian populations of cacao, allocating benefits by type and by sector obtaining the benefit (Prescott-Allen & Prescott-Allen 1986).

The classification of benefits in Table 2.6 is equivalent to the classification of stresses in Table 2.4. With the help of this classification it is possible to quantify benefits along the lines of the example in Table 2.7. As with stresses, estimates will be rough to start with but can be improved over time. This procedure will enable answers to be developed to the following questions:

C2.1. What and how much are the benefits obtained from extracted resources from domesticated species and converted ecosystems—by sector?

The sectors are likely to be: (a) agriculture; (b) silviculture; (c) aquaculture. Initially, this indicator could be developed for one sector.

C2.2. What and how much are the benefits obtained from extracted resources from wild species and unconverted ecosystems—by sector and by biodiversity component?

The sectors are likely to be: (a) forestry; (b) fishing; (c) hunting and trapping; (d) plant gathering; (e) tourism services? Initially, this indicator could be developed for one sector or for a major ecosystem.

C2.3. What and how much are the benefits obtained from on site resources by tourism services—total and by biodiversity component?

Initially, this indicator could be developed for one major ecosystem.

C2.4. What and how much are the benefits obtained from genetic resources—by sector?

The sectors are likely to be: (a) agriculture; (b) silviculture; (c) aquaculture); (d) chemical manufacture. Initially, the indicator could be developed for one sector.

C2.5. What and how much are the benefits obtained from genetic resources—by biodiversity component?

This breaks down the previous indicator by source population and ecosystem, to show the relative importance of domesticated and wild sources of germplasm, and the contributions of different populations and ecosystems.

C2.6. What and how much are the benefits obtained from species services—by sector and by biodiversity component?

The sectors are likely to be: (a) agriculture; (b) silviculture. Biodiversity components will include converted ecosystems and domesticated species (e.g., honey bees), as well as unconverted ecosystems and wild species.

C3. HOW MUCH BENEFIT IS OBTAINED PER UNIT OF STRESS?

Relating benefits to stresses requires the information contained in Annex 2: Using Performance Indicators. In simplest terms, once performance indicators are developed for the sections on benefits and stresses above, then they can be scaled and combined using the procedures in Annex 2. The ratio of benefit to stress is taken once all of the stress indicators have been combined into a stress index, and similarly, all of the benefit indicators have been combined into a benefit index.

Although different stresses will be measured in different units (e.g., timber removals in cubic metres, aquatic pollution in milligrams of pollutant per litre, habitat loss in hectares), they can be combined into a measure of total stress using the combination procedure described in Annex 2. Similarly, although benefits are expressed in different units (yield, income, disease resistance, etc.), they can be combined into a measure of total benefit, using the combination procedure.

Once the questions on stresses and benefits have been answered for a given sector or biodiversity component, it will be possible to estimate the amount of benefit obtained per unit of stress for the sector or biodiversity component concerned. Hence, it is desirable to take the questions systematically, sector by sector, or biodiversity component by biodiversity component. This will speed up the point when a benefit/stress statement can be completed for a particular sector or biodiversity component.

C3.1. How much benefit is obtained by a given sector or use per unit of stress on the ecosystem?

Benefit may include value added and employment, as well as the benefits measured under question C2. The “ecosystem” here is the ecosphere as a whole, and includes the impact of the sector on land, water and air quality, as well as on biodiversity *per se* (there being little point in trying to isolate impacts on biodiversity). Therefore this indicator may require data from other assessments besides the biodiversity assessment.

Variant of this indicator:

a. Stresses and benefits of specific uses of specific ecosystems, communities, species, or populations. This shows the known impacts of each use on people and the ecosystem. Each use of a particular component of biodiversity is assessed separately. Stresses include impacts on the resource (the species, groups of species, or community being used) and the diversity and quality of the ecosystem of which the resource is part. Benefits include the flow of products, income and other values to the people who harvest the resource and (if they are different) the people who control the resource or who have a major influence on it (either directly or via the ecosystem).

C3.2. How much benefit is obtained from a given biodiversity component per unit of stress on that component?

The biodiversity component may be an ecosystem or habitat, or a harvested stock of timber (or other plants) or fish (or other animals). The condition of the biodiversity component is measured using the indicators of status described under question B and the indicators of stress described under question C1. Eventually, the results could be summed into a statement of benefit per unit of stress on the entire ecosystem under review.

C3.3. How many specific uses are considered to be sustainable, and what percentage is this of the total number of specific uses assessed?

The answer would be based on C3.1 and on the combination of benefits and stresses considered to be sustainable (to be defined in the performance criteria).

C3.4. How many ecosystems/communities/species/populations are considered to be used sustainably, and what percentage is this of the total number of ecosystems/communities/ species/populations assessed?

The answer would be based on C3.2 and on the combination of benefits and stresses considered to be sustainable (to be defined in the performance criteria).

Issue	Indicator
Health	Life expectancy at birth. Infant mortality rate. Child mortality rate. Maternal mortality rate.
	Mortality & morbidity/disability rates from tuberculosis, HIV/AIDS, malaria, tobacco-related diseases, violence/trauma, other diseases
Population	Population; sex ratio; age distribution; dependency ratio; population density
	Population growth rate; crude birth rate; crude death rate; net migration rate
	Total fertility rate
Food sufficiency	% of households/population with sufficient food; % of children under 5 years who are stunted
Basic Services & shelter	% of households/population with access to safe water
	% of households/population with access to basic sanitation
	% of households/population living in shelter that is structurally safe & sited on safe land
Income	Personal income/personal disposable income
Economic activity	Gross Domestic Product (GDP); GDP per person (local currency or purchasing power parity dollars); GDP per unit of labour/capital/energy/materials
Economic Conditions	Unemployment rate. Inflation rate
	Budget balance; public debt. External debt.
	Saving & investment rates
Education	Net/gross primary/secondary/tertiary school enrolment rates.
	Adult literacy rate; % of children reaching grade 5.
Freedom & Participation	Observation of political rights, economic freedoms, freedoms of belief & expression, social freedoms, & legal rights.
	Participation rates in elections/government/other institutions.
Peace & Order	Deaths from armed conflicts. Military expenditure as % of GDP.
	Homicide/rape/assault/robbery rates; other crime rates.
Household & Ethnic equity	Ratio of richest 20%'s income share to poorest 20%'s; Gini coefficient
	Ethnic/other group disparities in indicators of health, wealth, education, human rights
Gender Equity	Female share of earned income. Difference between male & female school enrolment rates.
	Women's share of decision-making posts.

Table 2.8. Selection of basic indicators of human wellbeing.

C4. WHAT ARE THE MAIN SOCIAL AND ECONOMIC FACTORS BEHIND THE STRESSES?

The stresses imposed by people on biodiversity are due to a variety of social and economic factors, including health, population growth, poverty and the need to increase standards of living, the desire for profit and economic growth, institutional failings (including inadequate and perverse incentives), and maldistribution of wealth, power and information. Each situation needs to be analyzed to determine the most pertinent indicators. The indicators may already be included in other assessments, such as economic reviews, health assessments, and reports on sustainable development. Table 2.8 lists a selection of basic indicators.

C5. WHO GETS THE BENEFITS FROM BIODIVERSITY COMPONENTS AND HOW ARE THEY SHARED?

How the benefits of biodiversity are distributed strongly affects both the contribution of biodiversity to human wellbeing and human impacts on biodiversity. Distribution includes both the allocation of benefits within the broad sectors identified in the section on benefits (C2) and the flow of benefits from those sectors to other sectors or social groups. A basic division within each sector is between commercial and household. Commercial may be defined as production for the market by businesses larger than self-employed individuals or households. Household is production by households (and individuals), and may be subdivided into production for sale and production for own use. The commercial/household division is often a source of inequity and friction, for example between commercial trawlers and artisanal fishers. Inequities may also occur within those divisions—among regions, among ethnic groups, between rich and poor, and between males and females.

Key questions are:

C5.1. What percentages of a specified benefit obtained or received by specified groups?

> This indicator shows how a particular benefit is shared. It depends on answers to questions C2.1 through C2.6, to determine the total of the benefit concerned. If the benefit is denominated in money, then calculation of the share is straightforward. If it is expressed in physical units, it will need to be converted to a common unit (usually money) to calculate the shares. The mechanism for sharing could also be described.

C5.2. What is the flow of benefits from a specified genetic resource?

This indicator tracks the distribution of benefits from use of a specific genetic resource. Taking the example of germplasm from Peruvian populations of cacao (Table 2.7), the starting point is determination of the physical contribution of the resource (average 70% increase in yield). Then it is necessary to identify where hybrid cultivars containing the germplasm are grown, confirm the physical contribution (in this case, the size of the yield increase) in each growing area, and determine the proportion of production accounted for by those cultivars. Then calculate the value of that production, and hence the value of the increased yield. Finally, it is desirable to show the distribution of the increased income: corporate profits, wages, etc. An even more ambitious version of this indicator would also determine the costs of discovering, testing and maintaining the germplasm and of developing and growing the cultivars, and show how the costs are distributed.

Additional Research on Benefit-Sharing

In addition to monetary measures of benefit-sharing, recent research is starting to develop an understanding of how non-monetary benefits can be accrued (UNEP/CBD/COP/5/8). Users of this guide should be aware that benefits from components of biological diversity can include non-monetary items such as participation in research, capacity building (individual and institutional), technology transfers and increased in-country knowledge about biological diversity.

Examples may include:

- Participation of nationals in research activities
- Sharing of research results
- A set of voucher specimens left in national institutions
- Support for research for the conservation and sustainable use of biotechnology
- Strengthening capacities for technology transfer, including biotechnology
- Strengthening the capacities of local and indigenous groups to conserve, use and negotiate benefits from the use of their genetic resources
- Reasonable access to specimens deposited in international ex situ collections
- Reasonable access to technology developed through collaboration or use
- Protection of local existing application of intellectual property rights
- Increased capacity for control over bioprospecting, biodiversity monitoring and conservation
- Institutional capacity building
- Intellectual property rights
- Development of biological inventories and taxonomic studies
- Public-health benefits arising from pharmaceutical research
- Human and material resources

(Adapted from UNEP/CBD/COP/5/8: 14-15)

This is only a partial list of an emerging research area in biological diversity. Users of this guide should feel encouraged to develop monetary and non-monetary measures of benefit-sharing that best reflect their situation, and share the results of this work with others.

C5.3. Who benefits from the main stresses on a specified biodiversity component and who receives the benefits from that biodiversity component?

Different groups have different benefit/stress relationships with particular biodiversity components. For example, tourists may benefit from watching animals, whereas villagers may benefit from hunting them. A logging company may benefit some members of the community but reduce populations of plants and animals that benefit other members of the community. Such discrepancies are often at the heart of ineffective conservation or unsustainable use of species and ecosystems.

D. WHAT IS BEING DONE TO IMPLEMENT THE CBD AND IMPROVE THE STATE OF BIODIVERSITY?

This question responds to the requirement to report on measures to implement the CBD. Implementation of the CBD and other actions to improve the state of biodiversity can be assessed by asking three sets of questions:

D1. What procedures have been instituted to implement the CBD and improve the state of biodiversity?
D2. What provisions have been made to implement these procedures?
D3. What actions have been taken to implement these procedures?

D1. WHAT PROCEDURES HAVE BEEN INSTITUTED TO IMPLEMENT THE CBD AND IMPROVE THE STATE OF BIODIVERSITY?

D1.1 Has a national strategy/plan/programme been developed for conservation and sustainable use of biodiversity?

This shows whether Article 6 (a) is being implemented. Inputs to the strategy/plan/programme need to be recorded under question D2. Outputs need to be recorded under question D3.

D1.2. Do relevant sectoral or cross-sectoral plans/programmes/policies provide for conservation and sustainable use of biodiversity?

This shows whether Article 6 (b) is being implemented. The provisions need to be described, with inputs recorded under question D2 and outputs under question D3.

D1.3. What additional procedures have been instituted to implement the CBD and improve the state of biodiversity?

- Guidelines for the selection, establishment and management of protected areas [Article 8 (b)].
- Integration of consideration of conservation and sustainable use of biological resources into national decision-making [Article 10 (a)].
- Incentive measures [Article 11].
- Research and training [Article 12].
- Public education and awareness [Article 13].
- Impact assessment and minimizing adverse impacts [Article 14].
- Access to genetic resources [Article 15].
- Access to and transfer of technology [Article 16].
- Exchange of information [Article 17].
- Technical and scientific cooperation [Article 18].

- Handling of biotechnology and distribution of its benefits [Article 19].

D2. WHAT PROVISIONS HAVE BEEN MADE TO IMPLEMENT THESE PROCEDURES?

- Legislation or other regulatory provisons for the protection of threatened species and populations [Article 8 (k)].
- Financial and other support for *in situ* conservation [Article 8 (m)].
- Financial and other support for *ex situ* conservation [Article 9 (e)].
- Financial resources [Article 20].

D3. WHAT ACTIONS HAVE BEEN TAKEN TO IMPLEMENT THESE PROCEDURES?

D3.1. Has a system of protected areas been established to conserve biodiversity?

The indicator “Protected area as a percentage of each ecosystem” shows implementation of Article 8 (a), and how much of each major ecosystem is protected from uses incompatible with maintaining the diversity and integrity of the ecosystem.

IUCN defines six management categories of protected area in two groups. *Totally protected areas* are maintained in a natural state and are closed to extractive uses. They comprise Category I, Strict Nature Reserve/Wilderness Area; Category II, National Park; and Category III, National Monument. *Partially protected areas* are managed for specific uses (e.g., recreation) or to provide optimum conditions for certain species or communities. They comprise Category IV, Habitat/Species Management Area; Category V, Protected Landscape/Seascape; and Category VI, Managed Resource Protected Area (IUCN CNPPA 1994).

Totally protected areas are necessary to protect as wide a range as possible of intact communities and the species that depend on them. For such communities to persist and evolve “naturally”, buffered as far as possible against human activities, the areas need to be large. *Partially protected areas* are useful when certain human activities are actually required to protect particular species or communities. They are also necessary to protect landscapes and seascapes as valued expressions of human relationships with nature. The size of the area is usually less important.

Therefore, it is desirable to distinguish: (a) the total percentage of the ecosystem area that is covered by totally protected areas; (b) the percentages of the ecosystem area covered by totally protected areas in different size classes (e.g., < 1 000 ha, ≥ 1 000 ha, ≥ 10 000 ha, ≥ 100 000 ha, ≥ 1 000 000 ha [larger size classes are possible only in large countries]); (c) the total percentage of the ecosystem area that is covered by partially protected areas. A further refinement (seldom attempted) would be to distinguish protected areas that are effectively protected from those that are not.

In situations where protected areas cannot be assigned to major ecosystems—e.g., if a suitable ecosystem classification is not available—an alternative indicator is terrestrial (land + inland water) protected area as a percentage of the total terrestrial area, and marine protected area as a percentage of the total marine area.

The distinction between terrestrial and marine protected areas is necessary partly because the information is useful and partly because marine protected areas usually occupy a much smaller proportion of the total marine area than terrestrial protected areas do of the total terrestrial area. If the two were combined, it would distort the results. The marine area could be the continental shelf area or the Exclusive Economic Zone (EEZ). It is desirable to distinguish (separately for terrestrial and marine): (a) the percentage of the total area that is covered by totally protected areas; (b) the percentages of the total area covered by totally protected areas in different size classes; (c) the percentage of the total area that is covered by partially protected areas.

D3.2. How many threatened species are maintained in protected areas and what percentage is this of the total number of threatened species?

It is necessary to determine that viable populations are being maintained and not just that the species are present.

D3.3. How large an area of degraded ecosystem (a) is undergoing rehabilitation and restoration, (b) has been rehabilitated and restored, and what percentages are (a) and (b) of the total area of degraded ecosystem?

Shows implementation of part of Article 8 (f).

D3.4. How many threatened species are (a) the subject of recovery plans, (b) recovering, or (c) no longer threatened, and what percentages are (a), (b) and (c) of the total number of threatened species in the group concerned?

Shows implementation of the other part of Article 8 (f).

D3.5. What is the status and trend of introduced species?

Shows implementation of Article 8 (h). It can be measured by introduced (alien) species in a group (e.g., birds, bivalve molluscs, flowering plants) as a percentage of total species in that group. A variant of this indicator is to make it specific to a particular ecosystem: for example, introduced flowering plant species in the prairie ecozone as a percentage of total flowering plant species in the prairie ecozone.

An additional indicator would record the numbers of introduced species in a group that are (a) subject to a control programme, (b) have been effectively controlled [needs to be defined], (c) subject to an eradication programme, or (d) have been successfully eradicated, together with (a), (b), (c) and (d) as percentages of the total number of introduced species in that group.

D3.6. What additional actions have been taken for *in situ* conservation?

- Regulation or management of biological resources important for biodiversity [Article 8 (c)].
- Protection of ecosystems, natural habitats, and maintenance of viable populations of species in natural surroundings [Article 8 (d)].
- Environmentally sound and sustainable development in areas adjacent to protected areas [Article 8 (e)].

- Regulation, management or control of the risks associated with the use and release of living modified organisms resulting from biotechnology [Article 8 (g)].
- Preservation and maintenance of knowledge, innovations and practices of indigenous and local communities [Article 8 (j)].
- Regulation or management of processes and activities that have a significant adverse effect on biodiversity [Article 8 (l)].

D3.7. How many threatened species are maintained in *ex situ* collections, what percentage is this of the total number of threatened species, and how many of these species have been reintroduced into their natural habitats?

Shows implementation of Article 9. It is necessary to determine that viable populations are being maintained and not just that the species are present.

D3.8. How many varieties or breeds of selected crop or livestock species are maintained in genebanks and what percentage is this of the total number of varieties or breeds of those species?

Shows implementation of Article 9 and the extent to which genebanks are maintaining the genetic diversity of particular species. Numbers are of course easier to determine than percentages, because the total number of varieties/breeds may not be known. Synonyms and genetic distinctiveness need to be resolved for this indicator. To ensure that varieties are actively maintained (and not merely stored), it is also necessary to know what regeneration policies are practiced (for example, by noting the percentage of accessions in a collection that has been regenerated in the past decade) (Reid *et al.* 1993). Another version of the indicator is the number of accessions maintained in genebanks, but since many accessions may be of the same variety, this would not show how much genetic diversity is being maintained.

D3.9. What additional actions have been taken for *ex situ* conservation?

Regulation or management of collection of biological resources from natural habitats for *ex situ* conservation purposes [Article 9 (d)].

D3.10. What actions have been taken for sustainable use of components of biodiversity?

- Measures relating to the use of biological resources to avoid or minimize adverse impacts on biodiversity [Article 10 (b)].
- Protection and encouragement of customary use of biological resources in accordance with traditional cultural practices that are compatible with conservation or sustainable use requirements [Article 10 (c)].
- Remedial action by local populations in degraded areas where biodiversity has been reduced [Article 10 (d)].
- Cooperative development by government authorities and the private sector of methods for sustainable use of biological resources [Article 10 (e)].

ANNEX 1: SUSTAINABILITY ASSESSMENT METHOD

(The following text on Sustainability Assessment is taken from the IUCN Resource Kit for Sustainability Assessment. The full text of the Resource Kit is available from the IUCN Monitoring and Evaluation Initiative – it includes a full description of the methodology, diagrams, illustrations, maps and participants and facilitators training notes)

What is Sustainability Assessment?

Sustainability is a specific method of system assessment – a way of assessing both human and environmental conditions and progress toward sustainable development. The system is a spatial area that serves as the basis for the assessment, and can be applied at any level, from global to local. Sustainability Assessment is intended to support national and local decision-making and can be used for reporting on Agenda 21 and international conventions such as the Convention on Biological Diversity.

Sustainability assessment helps users be more inclusive about the topics that are considered when assessing sustainability. The method not only asks participants to consider human and ecological wellbeing together, but also suggests a wide range of topic areas that should be applicable in any circumstance. Procedures have been developed to identify indicators that can be combined into indexes that help clarify what is otherwise a confusion of non-comparable numbers.

A full Sustainability Assessment implies the consultation of a wide range of stakeholders and collection of a considerable amount of data. In this context, the broad purpose of the assessment is to construct a systematic and shared vision of sustainability, which is in turn, supported by a strong information base. However, it is recognized that many users have neither the desire nor the resources to undertake such an activity. Accordingly, Sustainability Assessment can be scaled back to support a wide range of needs – reporting on international conventions, thematic assessments, as an input to strategic analysis and planning or for baseline analysis and impact studies. These topics are discussed in much more detail in the IUCN Resource Kit for Sustainability Assessment.

Using this Annex

This Annex describes the technical details about Sustainability Assessment, covering its key features and stages of an assessment cycle. The Annex has been set up to explore topics in progressively more detail. Sections on Key Features, The Six Stage Cycle and Notes on Measurement + Mapping + Narrative (below) give basic information about Sustainability Assessment. This is followed by a more detailed explanation of the Six Stage Cycle of Sustainability Assessment. Readers wishing only an introduction to Sustainability Assessment should not feel obliged to read the entire annex, and could stop with the detailed explanation of the Six Stages. These procedures can be used as part of a full Sustainability Assessment described in this Annex, or on its own with the guidance provided in the menu of options for assessing biological diversity discussed in the main body of this guide.

Key Features of Sustainability Assessment

The full method of Sustainability Assessment contains the following key features:

- Equal treatment of people and the ecosystem;
- A hierarchy of elements and objectives to help select indicators and define performance;
- A common framework of dimensions around which more specific and representative elements can be selected in a comprehensive manner;
- A procedure for developing indicators that can be combined using performance scales;
- An iterative six-stage cycle, that can form the long-term basis of monitoring and an action-evaluation cycle;
- Complementary use of narrative, mapping and measurement to record the process of engaging stakeholders and their decisions;
- A user-driven process.

The principles behind Sustainability Assessment encourage stakeholders to assess their assessment needs, and then build a comprehensive vision of sustainability, which is articulated using elements and indicators in an increasingly more specific manner. The method helps ensure that important elements are not missed in the process, and that the measurements are as clear as possible and can be combined to show overall sustainability as well a progress in key dimensions.

Sustainability Assessment is best explored through the Six-Stage Cycle. Users of this guide can gain an appreciation of the process of Sustainability Assessment through the Six-Stage Cycle in this Annex, and then refer to more technical information on performance indicators in the Technical Note on Performance Indicators.

Full application of Sustainability, through the Six-Stage Cycle, is highly recommended. However, it is recognized that many users of this guide will be only interested in developing indicators of biological diversity (Section B to D of this Guide) and how to make use of performance indicators. Choosing one or the other will depend on many factors, including availability of resources and capacity. Sustainability Assessment makes most sense if reporting for the Convention on Biological Diversity is combined with a range of other reporting and assessment requirements. It is possible to develop a Sustainability Assessment that provides the information and assessment requirements for a range of applications on human development and environmental sustainability.

Reporting on the Convention on Biological Diversity

The Convention on Biological Diversity (CBD) calls specifically for identification and monitoring in Article 7, particularly to determine progress with *in situ* conservation [Article 8], *ex situ* conservation [Article 9], and sustainable use of components of biodiversity [Article 10]. Assessment can ensure that the strategies, programmes and policies provided for in Article 6 are implemented and achieve the expected results, and to provide basic information on biodiversity (status, stresses, benefits) required for Article 14 on impact assessment and minimising adverse impacts. The CBD requires Parties to report on measures to implement CBD provisions and their effectiveness in meeting objectives [Article 26]. It also provides for the Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) to assess the status of biodiversity and the effects of measures taken to implement the Convention [Article 25].

All of these needs can be met by placing biodiversity assessment and CBD reporting within a sustainable development information and assessment system, using the framework of Sustainability Assessment (Figure 1). Biodiversity assessment would provide the system with information on the status and trends of the diversity of ecosystems, habitats, species, populations, and genetic lines; on sustainable use of the components of biodiversity; and on equitable sharing of the benefits of using genetic resources. In return, the system would be a source of information on these and other topics, obtained from other assessments, such as on the state of the environment or on social and economic conditions. Thus the system would be a repository of information from many sources besides biodiversity assessments, on which CBD reporting could draw as needed.

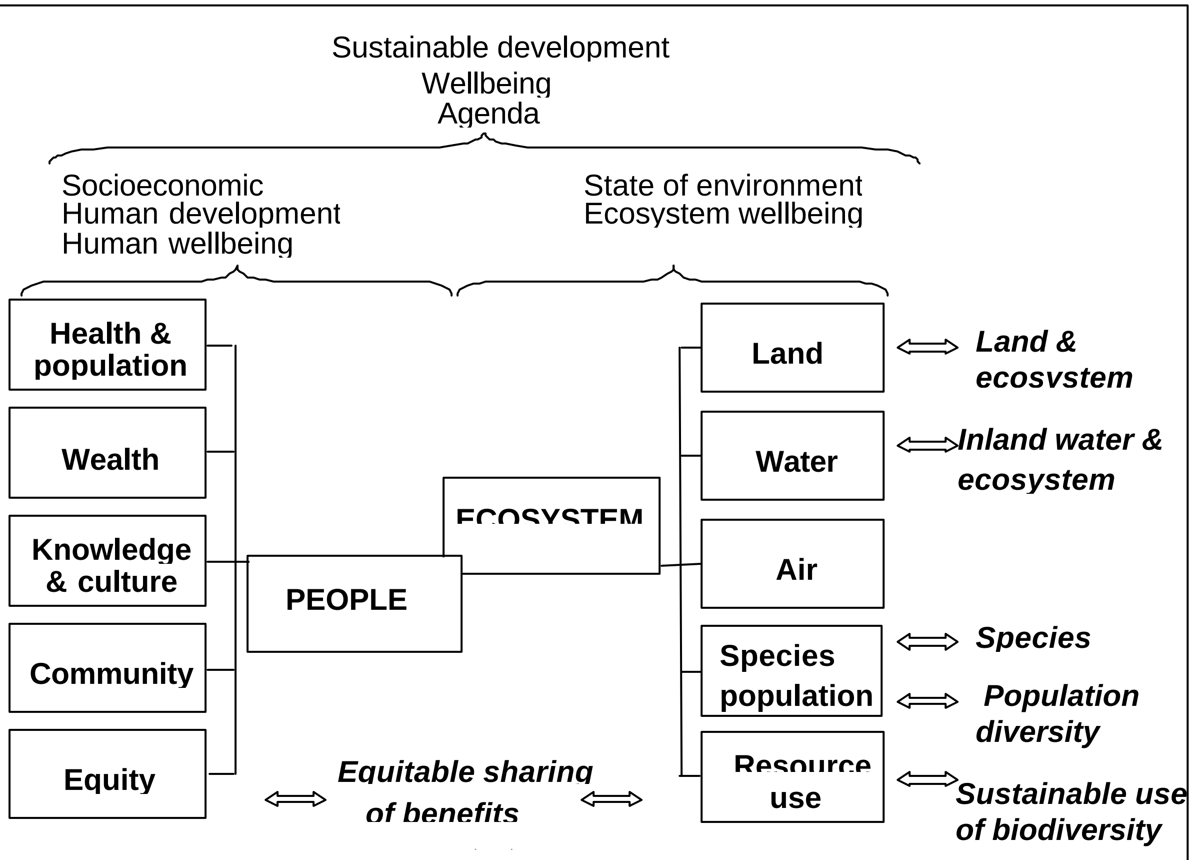

Figure 1*. Biodiversity assessment and reporting within the framework of sustainable development.*

Reporting on conventions asks the same questions as Sustainability Assessment but in reverse. For example, CBD reporting starts with the national strategy or action plan, examines how it is being implemented, and then assesses the results in terms of the CBD's objectives. Sustainability Assessment begins by measuring and analysing the state of the system (which corresponds to the results of the strategy), and then considers what is being done and what needs to be done to improve the situation (which corresponds to the strategy and how it is implemented). Because they work with the same questions, reporting and assessment have the same information needs. Fulfilling these needs through a single process reduces the burden and expense of reporting.

An Introduction to Sustainability Assessment: The Six Stages

Each sustainability assessment can be undertaken in a cycle of six stages. A cycle implies a continuous process, recognizing that assessments will be done repeatedly to show changes over time, and to support a broad range of decision-making needs.

The first four stages of the cycle are designed to help users articulate a shared vision of sustainability, that is defined in increasingly more specific ways, using elements, objectives, indicators and performance criteria. The aim of the first four stages is to unpack the components of a broadly defined vision into measurable indicators. The first four stages of the cycle move participants from the general to the specific.

The last two stages help users to assess overall human and ecological wellbeing from the individual indicators, by combining and reviewing. This approach uses performance scales for indicators to help provide a common unit by which indicators can be combined. If indicators are combined, they can be used to show aggregate performance and overall human and ecological wellbeing. All of this information, from individual indicators to aggregated indexes, can be used to aid an assessment of performance and identification of priorities.

The stages are (Figure 2):

1. ***Define the system and goals***. The *system* consists of the people and ecosystem of the area to be assessed. The *goals* encapsulate a vision of sustainable development and provide the basis for deciding what the assessment will measure.
2. ***Identify elements and objectives***. *Elements* are key concerns or features of human society and the ecosystem that must be considered to get an adequate sense of their condition. They are grouped under *dimensions*. *Objectives* break the identified system goal(s) into specific parts that relate to each element.
3. ***Choose indicators and performance criteria***. *Indicators* are measurable and representative aspects of an issue. *Performance criteria* are standards of achievement for each indicator.
4. ***Measure and map the indicators***. Indicator results are recorded in their original measurements, given scores on the basis of the performance criteria, and mapped.
5. ***Combine the indicators and map the indices***. Indicator scores are combined up the hierarchy: indicators into sub-issue indices; sub-issue indices into issue indices; issue indices into dimension indices; and dimension indices into

subsystem indices (separate indices for people and the ecosystem). Indices are mapped to reveal visually overall findings and specific patterns of performance.

6. ***Review results and propose policies***. The review links the assessment to action by analysing the patterns and the data behind them to suggest what actions are needed and where. The review also provides the diagnosis for the design of programs and projects.

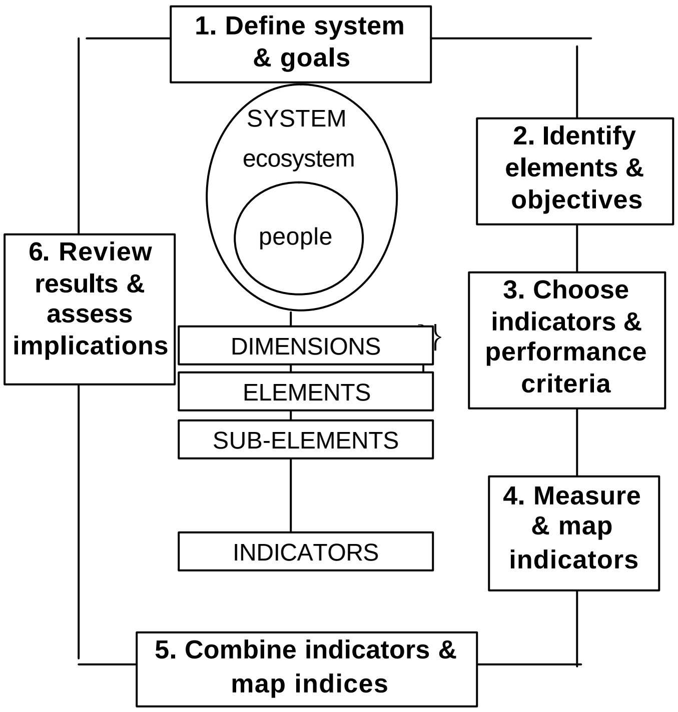

Figure 2. Six-stage assessment cycle (the hierarchy of elements and objectives is in the centre)

Only once the framework of goals, (sub)elements and objectives is adopted are indicators chosen to represent the (sub)elements. This helps provide a stronger and more comprehensive framework by which relevant indicators can be chosen.

By comparison, in most other assessment approaches, informal methods like brainstorming and canvassing are used to identify indicators, without going through the first two stages. This usually produces an unwieldy list of indicators, which then has to be reduced to a manageable number. For example, the city of Seattle's 'Sustainable Seattle' assessment started with 150 indicators, which eventually were reduced to 40 (Sustainable Seattle, 1995). If indicators are chosen in a conceptual vacuum, it is very difficult to know how important they are or how relevant to what people want to achieve. Therefore the first stages play a crucial role in this approach to sustainability assessment.

Notes on using Narrative + Measurement + Mapping in Sustainability Assessment

An assessment procedure will reflect people's aspirations and influence their decisions only if it is open to wide participation and scrutiny by the decision-makers who are expected to act on it and the citizens who are expected to live with the results. Therefore, not only does the assessment method need to be easy to use, but data must be made available to everyone and assumptions and judgements must be clearly stated. This will enable anyone to compare their own views and information against the basis for decisions made during a Sustainability Assessment.

To do this, Sustainability Assessment makes use of measurement, maps, and narrative to analyse and communicate the analysis. Each of these three tasks contribute in different ways during the six stages of an assessment (see Table 1).

Table 1. The role of measurement, mapping and narrative in the six stages

	Measurement	***Mapping***	***Narrative***
Stage 1. Define the system and goals	No activity	Prepare base maps of the area	Define the area to be assessed. Describe a vision of wellbeing and sustainability for the people & the ecosystem. Define goals that encapsulate the vision. Record these decisions & how they were made
Stage 2: Identify elements and objectives	Compile and analyse a meta-database (database overview) for each issue	Identify sources of mapped data for each issue in the meta-database	Identify elements for all dimensions & an objective for each issue; explain your choices
Stage 3: Choose indicators and performance criteria	Define, review & choose indicators for all elements & sub-elements. Choose performance criteria for each indicator	No activity	Explain and justify all the indicators. Explain and justify the performance criteria.
Stage 4: Measure and map indicators	Set up database. Obtain existing data for the indicators. Organise monitoring systems & surveys to obtain new data. Calculate scores for each indicator.	Map locations of point data. Use the scores to map the indicators.	Draw attention to main findings and explain apparent anomalies.
Stage 5: Combine indicators	Combine the indicators into indices	Map the indices	Draw attention to main findings and explain apparent anomalies
Stage 6: Map indices and assess implications	No activity	No activity	Analyse performance, causes & policy implications. Propose policies & actions

Measurement provides a set of systematic information. Without it, the assessment would be a collection of impressions and anecdotes. Measurement involves data collection and then organising, recording and combining the data into a set of indicators to show conditions and trends. Numbers provide participants with a common language for defining performance standards and targets, against which they can consistently compare and evaluate societal and environmental changes.

Mapping is by far the most efficient and effective way of recording, analysing and communicating spatial indicators. All ecosystem indicators and most human indicators can be expressed spatially. Mapping greatly supports an ecosystem approach to assessment, by showing the distribution of ecosystems, changes in their size, composition and condition, and the effects of human decisions and actions. Maps also oblige participants to tie the measured data to specific locations, thus highlighting where information gaps lie and stimulating participants to seek further information for the whole area rather than only a few locations. The mapping decreases the likelihood of participants making sweeping statements about a general area based on only a few data sites, which is common practice. Maps can show how indicators are linked, and they aid data interpretation by revealing patterns of performance.

However, indicators and indices, even when mapped do not explain the subtleties and complexities of the assessment. That is not their job. They are distillations, headlines, and attention grabbers. “Listen up”, they say, “this is what’s happening, find out more”. The rest of the assessment process tells the rest of the story. This is why narrative must complement measurement and mapping.

Narrative, or written text, is critical to make explicit the subjective choices that are made throughout the assessment for one indicator or issue and not another, and to reveal the assumptions that underpin such choices. The narrative that accompanies Sustainability Assessment therefore describes the context in which the assessment is taking place, explains the choice of elements and indicators, draws attention to their strengths and limitations, and (where possible) fills gaps with supplementary data. It documents the analysis causes, consequences and implications, and draws conclusions. It explains the meaning of the measurements and maps, without which they would be less informative and could be misleading. It can reveal underlying assumptions, explore connections between indicators and the elements they represent, and show the relevance for policy and action.

Narrative is also useful for documenting the process of doing a Sustainability Assessment. It useful to document how decisions were made, or how consensus was reached, particularly in situations where a wide range of stakeholders were consulted. Basic information about who helped make the decision, how long it took, the major dissenting opinions (and alternative views) can be essential information for those outside the assessment process to understand how things proceeded. This information is often captured as part of “lessons learned” as part of a reporting process, but it is worthwhile to consider recording this as part of the narrative.

The combination of narrative discussed above can be helpful in locating the assessment in the broader context. For instance, a discussion of indicators and performance criteria can often lead into a rich discussion of how different elements of a geographic area interact with one another. This information has implications for how the assessment results are interpreted and should be recorded as part of the narrative.

The Six Stages of Sustainability Assessment

STAGE ONE: DEFINE THE SYSTEM AND GOALS

Stage	Narrative	Measurement	Mapping
1. Define the system and goals	• Define the area (the system) to be assessed. • Formulate a vision of wellbeing and sustainable development for the people and ecosystem of the area. • Define goals that encapsulate the vision. • Record these decisions and how they were made.	No activity	Prepare base maps of the system

Effective assessment hinges on properly defining the system and its goal. Without this definition, there is clarity neither about the unit being analysed (society and ecosystem) nor the overall vision for sustainable development. The system goal is defined by the participants who have stakes in the system being assessed, and is thereby valid for that particular society and ecosystem. By defining the goal, participants make explicit their vision of sustainable development, the future they seek for themselves, their community, and their environment. A properly defined goal makes it possible for participants to understand their present condition and where efforts for improvement can be concentrated.

Define the area to be assessed

The system comprises people (human communities, economies and related aspects) within the ecosystem (ecological communities, processes and resources), together with their interactions.

From an ecological perspective, the system consists of different spatial levels, from the planet as a whole to a particular habitat. Although the levels affect each other, the decision-makers and decision-making processes differ with each level. Individual members of households make key decisions at the habitat level, national governments at national level, and so on. Note that information is usually specific to a spatial level, because data is usually collected according to specific administrative units that are defined geographically. It is important to select the administrative level that promises the best opportunities for data.

Consequently, to use information efficiently and influence decisions, assessment participants need to start by defining a series of assessment levels. This will help them be aware that other levels exist, and to justify why they chose one on which they will focus the assessment work. This level is called the *focal level,* which is simply the highest spatial area on which the assessment will focus and is thereby defined by the outer boundary of the area to be assessed. The focal level of a national assessment of Bangladesh would be the entire country of Bangladesh, showing variations of wellbeing within the country and thus producing an overall picture. The focal level of a district assessment in Bangladesh would be a specific district, showing variations within the district.

An average picture in a large geographic area would not show specifically where, action is needed. Illustrating differences in performance spatially is the only way to be sure where to concentrate action. To show this variation within the focal level, it needs to be sub-divided into smaller units. Otherwise, information would only show average ecological and socio-economic conditions for the entire area and not differences that may occur from one part of the focal level to another. For example, an assessment of Asia that did not distinguish countries would portray the entire continent as uniform, as if conditions in Bangladesh were identical to those in Japan.

Drawing information from a lower level, known as the differentiation level, solves this problem. The differentiation level is usually the geographic unit or the level immediately below the focal level, and not lower. This is done in order to avoid dealing with too many units, as the number of units increases further down the hierarchy. For instance, an assessment of Italy could differentiate by 20 regions or 103 provinces. More units require data more data has to be collected. The result is a more costly assessment that is more difficult to communicate. In Italy, it is likely that an assessment would differentiate by the 20 regions, rather than the 103 provinces. There is a trade-off of which to be aware. If data is collected at the level of province and not region, then it would probably be necessary to differentiate at the provincial level. However, stakeholder consultations could still happen at the regional level, if a meaningful and clear aggregation of provinces into regions could be identified.

Spatial levels are most easily understood when defined in terms of administrative units (Figure 3) for two reasons. First, administrative units are the units of decision-making, and the assessment is meant to influence decisions. Second, most economic and social data are collected according to administrative units. However, spatial levels may also be defined ecologically (e.g., ecoregions), hydrologically (e.g., drainage basins), or in other ways.

The ideal choice of focal/differentiation levels for an assessment is the one that is most useful for decision making, most revealing for analysis, and most practical for data collection. It may not be possible to satisfy all these criteria.

The choice of focal level depends on two factors: the purpose of the assessment; and the likely number of differentiation levels. This is often a straightforward decision. An assessment to support national decision-making, by definition, must cover the nation. Selecting a focal level can be tricky sometimes, especially when the purpose of the assessment is to analyse the context of a project that covers a watershed or ecosystem that cuts across administrative boundaries. In cases like this, the focal level needs to encompass the watershed or ecosystem concerned *and* the administrative units that it overlaps. What is the best unit for the differentiation level? An assessment is not merely an information gathering exercise. To be effective, assessments require the participation of decision-makers and those who influence them in the area being assessed. Hence a differentiation unit is a source of data and helps define who should, ideally, be a participant.

In the case described above, the choice of differentiation level involves choosing between many units and few units. An assessment can be more finely detailed and show more of the variation that exists within the area when more units are used. Having many units also makes it easier to reorganise data according to ecological and hydrological units. Census units collect much social and economic information.

By placing this information into a geographically-referenced database, the units, and the data, can be separated from their administrative blocks and recombined into ecoregional and drainage basin blocks. Using many units however, has the disadvantage of making the assessment logistically difficult more expensive to conduct.

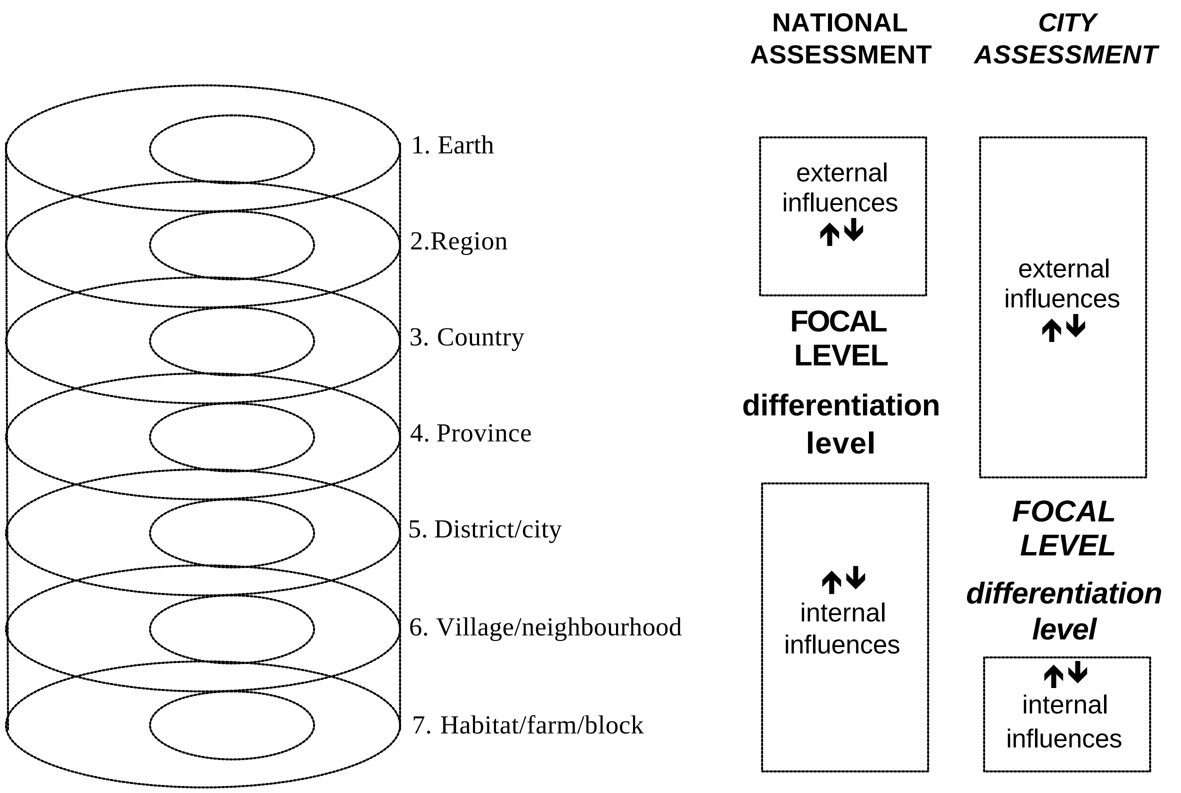

Figure 3 Focal and differentiation levels: examples of a national and a city

Develop a Vision of Wellbeing and Sustainable Development

Participants develop a shared view of what world they are aiming to create by painting their own picture of wellbeing and sustainable development. This picture becomes the basis for defining goals and objectives. It is the standard against which the assessment will measure progress. A vision is not a plan. It is an ideal future scenario that has been made explicit, and explained as if it has already happened. These ideas strongly influence why people say what they say, do what they do and set priorities.

Visions are best guided by questions that trigger creativity and enable people to move beyond short term tasks to discuss longer term aspirations. Such questions or statements can include :

- What kind of world are our actions creating? Is this the world we want to live in? If not, what would we like to change?

- Where do we want to be in 20 years from now?
- If I could have my ideal world now, I would show….”

Any Sustainability Assessment will synthesize these the answers to such questions in a short and simple guiding statement or goal.

The vision could also consider sustainability according to its components. Sustainability assessment uses a Common Framework of Dimensions to help organize the detail of the assessment. The dimensions and their possible elements are listed below Box 1. Using the dimensions during the visioning process can help guide the process by giving some specific areas around which to have discussions and elaborate the vision.

Box 1. Key Feature: A Common Framework of Dimensions

Sustainability Assessments use a common framework of five human and five ecosystem dimensions (see Figure 2.3). The dimensions were chosen after development and testing in a variety of field sites, and are intended to provide a common starting point for all assessments. Within this framework, users select their own elements and indicators. An important rationale for common dimensions is to ensure that important elements are not missed in the assessment process.

The framework is designed to combine a wide range of elements into a few major groups of roughly equal importance. The dimensions of these groupings are comprehensive enough to accommodate the majority of concerns of most societies: any issue regarded as significant for wellbeing and sustainable development has a place in one of the dimensions. They represent non-technical and accessible concepts (wealth, water, etc.). Because they are equally important, they are easily combined into indices of human and ecosystem wellbeing. A common framework of dimensions allows assessments to be tailored to local conditions and needs and at the same time makes comparison with other Sustainability assessments easier.

A fairly comprehensive sample of possible elements in each dimension includes:

- *Health and population*: physical and mental health, disease, mortality, fertility, population growth.
- *Wealth*: the economy, income, material goods, infrastructure, basic needs for food, water, clothing and shelter.
- *Knowledge and culture*: education, state of knowledge about people and the ecosystem, communication, systems of belief and expression.
- *Community*: rights and freedoms, governance, institutions, peace, crime, civil order.
- *Equity*: distribution of benefits and burdens between males and females and among households, ethnic groups and other social divisions.
- *Land*: the diversity and quality of land ecosystems including their modification, conversion, and degradation.
- *Water*: the diversity and quality of inland water and marine ecosystems; modification by dams, embankments, pollution, and water withdrawal.
- *Air*: local air quality and the global atmosphere.
- *Species and populations*: status of wild species and wild and domesticated (crop and livestock) populations.
- *Resource use*: energy and materials, waste generation and disposal, recycling; resource sectors such as agriculture, fisheries, timber, mining, and hunting.

Define Goals that encapsulate the Vision

Formulating the goal is the first step towards enabling participants to arrive at an operational and measurable definition of sustainable development. A goal sets out a standard of achievement, however general it might appear at this level. Goals remind participants of their vision and provide the basis for deciding what the assessment will measure. A key feature of Sustainability Assessment is the equal treatment of people and the ecosystem (see Figure 4 and Box 2). Operationally, this means that goals are identified for both.

Goals are needed for the system as a whole and for people and the ecosystem, and can be simple statements, for example:

- *System* goal: human and ecosystem wellbeing improved and maintained.
- *Human* goal: human wellbeing improved and maintained.
- *Ecosystem* goal: ecosystem wellbeing restored and maintained.

Participants in a village assessment in Zimuto communal land area, Zimbabwe, defined their goals as follows:

- System goal: a secure and harmonious community in a productive and diverse ecosystem.
- Human goal: secure livelihoods and strong communities.
- Ecosystem goal: a more productive ecosystem with its biodiversity restored and maintained.

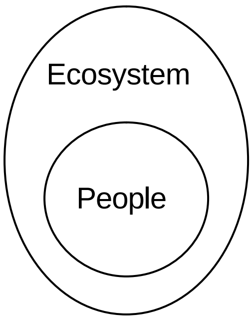

Figure 4. The Egg of Sustainability shows a key feature of this method, that the wellbeing of people and the ecosystem are treated equally.

When more than one organisation or group is involved in the Sustainability Assessment, special attention will be needed so that that all participants can recognise their input, and interests in the goal. This means forgoing individual, organisation-specific mandates/goals and formulating a new, shared goal that will guide the assessment process.

Box 2. Key Feature: Equal Treatment of People and the Ecosystem

The core principle of Sustainability Assessment is that sustainable development is a combination of human wellbeing and ecosystem wellbeing. Human wellbeing is defined as a condition in which all members of society are able to determine and meet their needs and have a range of choices to meet their potential. Ecosystem wellbeing is defined as a condition in which the ecosystem maintains its diversity and quality, and thus its capacity to support people and the rest of life, plus its potential to adapt to change and provide a wide range of choices and opportunities for the future.

The two parts are like an egg, the Egg of Sustainability (Figure 4). People depend on the ecosystem which surrounds and supports them much as the white of an egg surrounds and supports the yolk. At the same time, a healthy ecosystem is no compensation if people are victims of poverty, misery, violence or oppression. Just as an egg can be good only if both the yolk and white are good, so a society can be well and sustainable only if both people and the ecosystem are well.

Human wellbeing is inherent in the idea of sustainability, as it would be unimaginable to want to perpetuate a low standard of living. Ecosystem wellbeing is a requirement because it is the ecosystem that supports life and makes possible any standard of living. Trade-offs between the needs of people and the needs of the ecosystem will always exist but can be limited and short term, rather than permanent. Ultimately, human and ecosystem wellbeing are equally important, and a sustainable society needs to achieve both together. Hence a logical goal for every society is ***to improve and maintain the wellbeing of people <u>and</u> the ecosystem***.

For these reasons, Sustainability Assessment considers the wellbeing of people and the ecosystem together but measures them separately. Information is organised into two sub-systems, or branches of the system: people (human communities, economies and artifacts); and ecosystem (ecological communities, processes and resources). As these two subsystems interact, the interactions between them, such as 'resource use,' are placed within the subsystem where the impacts are felt. Accordingly, human stresses on the ecosystem (resource depletion, pollution, etc.) and benefits to the ecosystem (conservation) are recorded under 'ecosystem'; and ecosystem benefits to people (economic resources, health, etc.) and stresses on people (natural disasters, etc.) are recorded under 'people'.

The division of people and ecosystem into two equal branches of reflection, measurement, and analysis allows for comparison between progress in human development and ecosystem conservation. It is not possible to measure sustainability *per se* as we simply do not know what combinations of human and ecosystem wellbeing would be sustainable. However, most societies would consider themselves more likely to be sustainable if their human wellbeing and ecosystem wellbeing are both high, i.e. when ecosystem stress (the opposite of ecosystem wellbeing) is low. Progress toward sustainability can therefore be shown by the ratio of human wellbeing to ecosystem stress.

Record how these decisions were made and prepare base maps of the area

It is important to record the decisions made regarding focal level, differentiation level and goals, for the benefit of participants and others who could learn from the assessment. The agreed upon vision, and any proposed alternatives, will be recorded, as well as the process by which the decisions were made and the vision formulated. Information about which group was involved, what they did, and when they did it should also be included in the record.

Participants can begin preparing the base maps needed to locate the indicator values that are calculate in Stage 4 (see Section 7). This involves deciding which map scale to use and the level of detail that will communicate the information without excessive investments of resources.

The content of a base map varies with the nature of the assessment. Each will be placed on the map like layers that can then be assessed together. Four types of information are usually required:

- Administrative boundaries of focal and differentiation levels. If the focal level is country and the differentiation level is province, then the layer should show the boundaries of the provinces. If the focal level is district and the other level is village, the maps should show the outlines of the villages.
- Human settlements and other infrastructure.
- Drainage basins and aquatic features.
- Vegetation formations or other ecosystem or habitat units.

If ecological and hydrological units are being used as additional differentiation levels besides administrative units, they will need to be placed on the map as well. The layer of drainage basins and aquatic features will serve as the hydrological layer of information. The ecological layer may follow agroecological zones or an ecoregional classification different from a map of vegetation. In this case, the ecological layer would warrant a map layer of its own.

Key Feature: The Hierarchy of Elements and Objectives

It is not possible to measure progress toward sustainability directly. Sustainability Assessment—like any other assessment method—measures sustainability by assessing individual aspects. In this method, individual indicators, which are measurable, are representative of elements, which in turn are representative of dimensions. Five human and five ecosystem dimensions are used to organise elements by theme. The hierarchy allows users to simultaneously see the detailed performance (indicators), while affording an appreciation of the big picture (wellbeing of people and the ecosystem).

A hierarchy of objectives provides a matching series of stepping stones from overall goal to specific performance criteria, helping users to translate the concept of sustainable development into concrete improvements in people's lives and the condition of the ecosystem.

Since it is impossible to account for everything, and no instrument exists for measuring wellbeing and sustainability directly, assessments measure representative aspects, or indicators. Indicators require the collection and analysis of, often, large amounts of data. This data can become a mess of numbers. The challenge, therefore, is to identify those features that reveal most about the state of the system, using the fewest possible number indicators.

In Sustainability Assessment, ensuring the message is not lost amidst the indicators is made possible by using the hierarchy, which starts with the system and its goal, and moves via increasingly specific elements and objectives to measurable indicators and performance criteria. The hierarchy of *elements* ensures that a manageable set of indicators reveals key aspects of human and ecosystem wellbeing in the system being assessed. Combined with analysis, it can help users of the assessment to understand how well the indicators represent key features of the system and their relationship to each other. The hierarchy of *objectives* helps users to focus the assessment on what needs to be undertaken to achieve sustainable development. It also provides a logical way of converting general concepts of sustainable development, wellbeing and progress, into a set of explicit human and environmental conditions.

STAGE TWO: IDENTIFY ELEMENTS AND OBJECTIVES

Stage	Narrative	Measurement	Mapping
2. Identify elements and objectives	Describe elements and an objective for each issue, and explain why they were chosen.	Compile a meta-database and identify who knows what—the sources of information on each issue.	Identify sources of mapped data for each issue.

Elements are key subjects or concerns, features of the ecosystem or society that must be considered in order achieve an adequate sense of their condition. These elements are formulated in general terms: 'livelihood opportunities,' 'formal education,' 'status of women,' 'soil quality,' 'availability of water supply,' 'crop biodiversity.' Elements and their objectives serve as the bridge between the general and intangible, system goal and the specific, measurable, indicators and performance criteria (see Section 6).

The selection of elements and sub-elements is one of the most important parts of an assessment. Elements determine what the assessment will measure, and therefore directs the assessment's conclusions. Should elements that are widely recognised as important for sustainable development be omitted, the usefulness, and credibility of the assessment will suffer. The challenge for participants during assessment is to agree on a representative number of elements that together capture the essentials of ecosystem wellbeing, human wellbeing, and the nature of their interaction within the system being assessed.

Elements are grouped into a core set of dimensions. The dimensions are intended to be common to all Sustainability Assessments and help to ensure that attention is paid to all main themes within both sub-systems. The dimensions have been chosen to provide a common framework for a wide range of assessments from national Agenda 21 reports, through thematic assessments such as a biodiversity assessment, to local and project-based assessments. Dimension can be thought of as conceptual boxes used for organising elements that can accommodate most of the concerns of most societies. Figures 5 and 6 display the set of dimensions and examples of elements.

If elements are too broad to measure directly, then they should be divided into sub-elements. This is not always necessary. Just as goals are defined for the system and for the subsystems of people and ecosystem, more specific objectives are defined for the elements and sub-elements. Table 2 gives examples of dimensions, elements and sub-elements and their corresponding objectives.

Level	Ecosystem example	Human example
DIMENSION	Species and populations: *Minimal loss of species diversity; maintenance of as much population diversity as possible*	Wealth: *A decent standard of living and a strong and self-reliant economy*
ELEMENTS	Species diversity: *Minimal loss of species diversity*	Household economies: *A decent standard of living*
SUB-ELEMENTS	[not necessary]	Food supply: *Sufficient food for everyone*

Table 2: Some examples of dimensions, elements and sub-elements. *Objectives are in italics.*

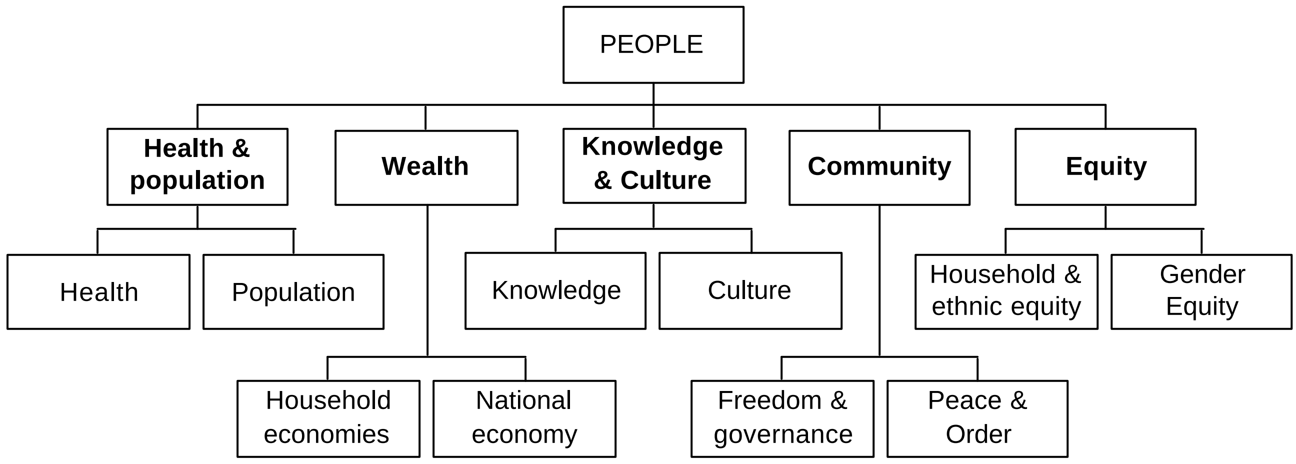

Figure 5. Human dimensions (in bold**) and**

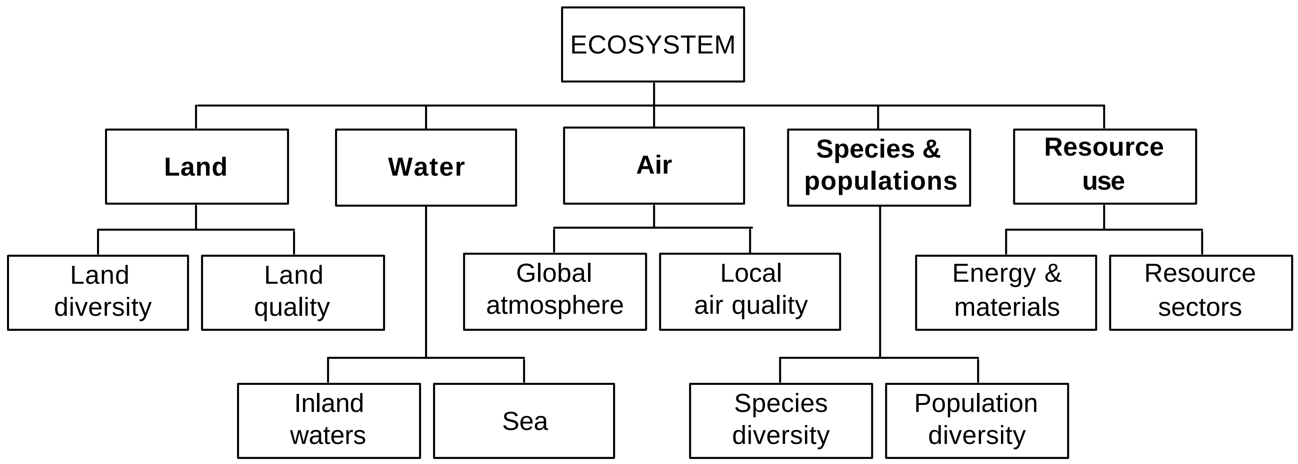

Figure 6. Ecosystem dimensions (in bold**) and**

The sustainability assessment method suggests using the recommended set of dimensions, but within that framework, there is plenty of scope for participants of the assessment to define elements that best represent their purpose, interests and circumstances. Each dimension should be represented by an element or set of elements (and perhaps sub-elements) that give anyone an adequate sense of the condition of that dimension.

Understanding the Resource Use Dimension

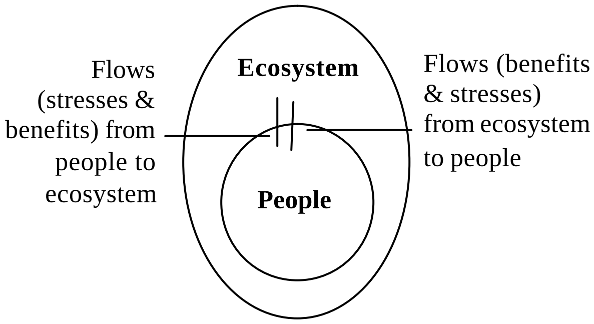

Figure 5.3. Subsystems of people and ecosystem, showing treatment

The 'resource use' dimension prompts the most questions: "Why is something that seems to refer to an aspect of wealth, i.e. under the human dimension, categorised as an ecosystem dimension?" The answer is that assessments consider not only the states of people and the ecosystem but also their interactions: the flows of benefits and stresses from the ecosystem to people and of stresses and benefits from people to the ecosystem (see Figure 5.3). These interactions need to be recorded somewhere and they cannot be recorded in two places. This would lead to double, and therefore incorrect, counting. The convention adopted by Sustainability Assessment is to record flows from the ecosystem to people under 'people,' and flows from people to the ecosystem under 'ecosystem.' The result is that 'income from timber' is recorded under people (wealth) and 'pressure on forests from logging' is recorded under ecosystem (resource use). Another example involves 'food': whether people have sufficient food is a human issue, whether food production leads to over-fishing is an ecosystem issue.

Resource uses are the major source of human pressure on the ecosystem. As signs of pressure, resource use indicators can warn of impending changes in the condition of the ecosystem. Measurements of ecosystem conditions are more difficult to obtain than are measurements of pressures from resource use. The state of the environment is likely to look better than it actually is if we do not include resource use indicators. In addition, resource use indicators can be designed to show pressure on the global ecosystem as well as pressure on the local ecosystem, for example: by factoring in imports. Most of the indicators of the other dimensions—land, water, air, species and populations—measure the state of the local ecosystem alone.

Identifying Objectives

Objectives are the goals specific to elements. Once the (sub)elements are clear and clustered under dimensions, the objectives for each issue need to be formulated. These 'issue objectives' specify the desired state for that particular issue. Without specific objectives per issue, it is impossible to know what to aim for in terms of system performance. Furthermore, problems will emerge in the next stage (see Section 6) when indicators and performance criteria are set, if the objectives are not clear.

Objectives should be identified for each issue and sub-issue (see Table 5.1). The objectives form a logical link in a chain of argument from the goals for people and the ecosystem to the performance criteria (standards of achievement) for each issue. For example, ecosystem wellbeing restored and maintained (ecosystem goal) by, among other things, maintenance of as much genetic diversity as possible (species and populations objective) through minimal loss of species diversity (species diversity objective) defined as performance criteria for threatened species indicator.

Defining objectives can be very helpful in sorting out elements and sub-elements, and obliging participants to be clear about why the issue or sub-issue has been included and what it covers. A definition of objectives will also help determine what its relationship is to the dimension concerned and to human or ecosystem wellbeing.

At this stage, some confusion might arise as to how concrete the objective should be. Project staff might tend to formulate objectives in terms of concrete activities, as they are used to operating at that level of specificity. However, issue objectives are stated in more general terms than project objectives and relate to the overall system vision or goal. Issue objectives describe how that issue contributes to the vision. As with the goal formulation, the question that can guide the formulation of issue objectives could be: '*How would you like to see the state of this issue in 20 years time?*,' or '*Twenty years from now, we want this issue to be …..'*

The truly iterative nature of wellbeing assessment emerges here, as it is difficult to formulate clear objectives for elements at the first attempt. In the next stage—that of formulating performance criteria—participants will often realise the inadequacy of the issue objectives that they have set and will need to return to the issue objectives before returning to the criteria formulation. Several cycles may be needed before the objectives are clear enough to formulate indicators and performance criteria.

For future reference and transparency, it is important to explain the reasons for choosing the elements, sub-elements and objectives, and to write the explanation down. It is also helpful to record the process by which the decisions were made: who was involved, what they did, and when they did it.

Compiling a meta-database

A meta-database is a compilation of information on data. Compiling this structure involves identifying the sources of information and mapped data on each element (for the focal and differentiation levels). It is a prerequisite for the next stage of choosing indicators.

This topic is explored in more detail in the technical annex on Performance Indicators. When doing a full Sustainability Assessment, it is important to compile the meta-database before choosing indicators, because a key criterion for selecting any single indicator is its feasibility, which is a direct function of data availability.

STAGE 3. CHOOSE INDICATORS AND PERFORMANCE CRITERIA

Stage	Narrative	Measurement	Mapping
3. Choose indicators and performance criteria	Explain and justify indicators and performance criteria.	• Choose, define and review indicators. • Decide performance criteria.	No activity

Choose Indicators

Indicators are measurable and representative aspects of an issue. Indicators can reveal insights about an aspect of the system being assessed. They can make complex phenomena quantifiable so that communication about the phenomena is made easier. Indicators can serve as generalisations at the global level when widespread consensus exists, or can be representative of highly context-specific situations. In the case of Sustainability Assessments, indicators will often be context-specific, as they need to reflect the dimensions, elements, and sub-elements that are pertinent to the system being assessed.

Indicators are evaluated by four criteria – measurability, representativeness, reliability and feasibility – to help decide whether they will be helpful, need adjustment or need substitution. Table 4 provides some guidance on this.

The need for a manageable, and therefore small, set of indicators makes it especially important to ensure high quality indicators. To be useful, indicators must also be *reliable* and *feasible*. At least one indicator should be chosen for each sub-issue (or issue, if there is no sub-issue). If the indicator is reasonably representative and fulfils the other criteria (measurable, reliable, and feasible), then it will be enough. If it is insufficiently representative or its reliability is suspect, then additional indicators will be needed.

To be useful, indicators need to be clearly defined. Undefined or ill-defined indicators are virtually impossible to use. It is difficult to communicate effectively when indicators can be interpreted in too many different ways. For example, 'area of natural land as a percentage of the total land area' is an imprecise indicator because 'natural' can mean different things to different people. Even when 'natural' is defined, for example as 'negligibly to lightly human-influenced; the scale and rate of human impact on the biological and physical composition of the ecosystem is of the same order as the impact of other species,' the definition leaves room for different interpretations.

A simple check of whether or not an indicator is *measurable* is to try to express it in quantitative rather than vague terms. An example of vague terms would be: "threatened species" or "people without enough food." Quantitative terms can be expressed as direct physical measurement or as opinion poll results. Opinion polls are acceptable as long as they are administered in a sound manner, are direct measures of what is being measured and are representative of the issue. Each of the indicators in Table 3 is expressed in a way that makes clear what is being measured: the number of faecal coliforms per 100 millilitres of water; the number of threatened species in a group as a percentage of threatened species in that group; the number of years that a new-born can expect to live; the number of people who are undernourished as a percentage of the total population. Indicators need to be defined as precisely as possible to give everyone involved the same understanding of what is meant.

Table 3. *Examples of Indicators*

Element	*Indicator*
Water quality	Faecal coliforms per 100 ml water
Species diversity	Threatened species in a group as a percentage of total species in that group
Health	Life expectancy at birth (years)
Food supply	Percentage of the population that is undernourished

An indicator is fully *representative* if it covers the most important aspects of the issue or sub-issue concerned, and demonstrates trends over time and differences between places and groups of people. ‘Life expectancy at birth’ comes close to being a fully representative indicator of health, since it reflects all the causes of death, and the death rates from those causes, that a typical person would be exposed to throughout life. Even so, it is incomplete, since it does not measure the number of years a person can expect to live with different degrees of disability or illness. An example of a non-representative indicator would be ‘low alcoholism rates’ as an indicator of the issue ‘community cohesion*.’* Yet community cohesion involves much more, including strong leadership, multiple community groups, and so on. This indicator is not representative, because it does not cover all the aspects of the issue that it is supposed to represent.

An indicator is more likely to be *reliable* if it is well-founded, accurate, measured in a standardised way with sound and consistent sampling procedures, and directly reflects the objective concerned. ‘Well-founded’ means that its relationship to the issue it represents is well established, scientifically valid, or is a defensible and testable hypothesis. For example, stunting (low height-for-age) in children is a well-founded indicator of lack of food, since many studies have demonstrated the relationship.

An indicator is *feasible* if it requires data that are readily available or obtainable at reasonable cost and effort. Such data will be available in a variety of forms and from a variety of sources. To determine feasibility, there is a crucial distinction is between: (a) data that are already collected as a matter of course and are available as maps, statistics, or both; and (b) uncollected data. The meta-database prepared in earlier stages should be able to show whether the data are already collected and provide additional information on collection, storage and access.

Table 4. What to do with indicators in each of the five quality classes

Indicator quality class	*What to do with the indicator*
The indicator is measurable, representative, reliable, and feasible.	Fine, use it.

The indicator is measurable, reliable, and feasible, but not sufficiently representative.	Use it and try to find one or more additional indicators until you feel the sub-issue or issue is adequately represented.
The indicator is measurable, representative, and feasible, but not very reliable.	Is it reliable enough to use, if everyone is made aware of its flaws? If yes, use it and try to find one or more additional indicators that together could produce a more reliable picture. If no, drop it, and try to find a substitute.
The indicator is measurable and feasible but not sufficiently representative or very reliable.	Is it reliable enough to use, if everyone is made aware of its flaws? If yes, use it and try to find one or more additional indicators that together could produce a more reliable picture. If no, drop it, and try to find a substitute. In any case, since the indicator has two significant problems, be more inclined to drop it than keep it.
The indicator is feasible, but not measurable, or not representative, or not reliable.	Forget about it.
The indicator is measurable, representative, and reliable, but not feasible.	Can the (sub)issue be represented reasonably by another indicator or set of indicators? If yes, drop the one first suggested. If no, re-examine the indicator's feasibility. Three may be a more creative and cost-effective way of finding the required data.

For data that are not being collected at present, it is necessary to determine:

- How, when and by whom the data will be collected, including standards for the precision and accuracy of records, and frequency of updates?
- Where, how and by whom the data will be stored?
- Who should have access to the data, how, and at what charge (if any)?
- What are the costs of collection and management and how will they be paid?

Answering these questions will make it possible to decide whether the costs of getting the data and maintaining the indicator are reasonable.

If no indicator that adequately meets the criteria can be found for a (sub)issue, then the sub-issue or issue should be excluded from the assessment. In such cases, it is important to discuss in the narrative that the (sub)issue is considered to be important but that it cannot be covered. The indicator will not appear in the measurement or mapping, but it will appear in the narrative.

Decide on performance criteria

Performance criteria are specific standards of achievement for each indicator selected. Performance criteria define what is considered the 'best' performance level, which represents the full achievement of the objective. Once this has been determined the performance criteria then helps define various levels of distance from that ideal, or degrees of achievement of the ideal, until it reaches the 'worst' level. An everyday example of performance criteria would be a discussion with friends after seeing a movie. This conversation may turn to judgements of the actors' performances, in which you might use terms of 'good,' 'medium' or 'bad.' In a Sustainability Assessments performance criteria helps translate the goals and objectives into more concrete measurable performance. Performance criteria also provide the basis for putting indicator results on a performance scale, so that these results can be combined.

Combining different indicators requires combining units that are not similar, like apples and oranges. To do this successfully requires that a measure be found that does not distort their unique qualities. One option is to convert the indicator measurements to a common unit. The possible option is to put the indicators on a performance scale.

By contrast, a *performance* scale measures how good an orange is at being an orange and how good an apple is as an apple. This is worded in terms of the difference between an average level of performance of apples/oranges and the actual performance of the apple/orange being assessed, as recorded by measuring the indicator. On a 0-100 scale, best performance would be 100 and worst 0. A given apple or orange would be assigned a score according to how it rated in relation to 'best' and 'worst.' Performance criteria, or the definitions of best and worst performance, for apples and oranges could be very different. However, since the scores apples and oranges are calculated in the same way on the same scale, in terms of a percentage, these scores can be combined.

A performance scale allows use of whatever measure or yardstick is most appropriate to the issue concerned. Income and value added are measured in money. But, health is measured in disease and death rates, employment is measured in jobs, species diversity in percentages of threatened species, land degradation as erosion rates, social cohesion in terms of participation in community groups, and so forth. Distortion is negligible because the original units in which the indicator is measured are maintained.

Setting performance criteria means defining what is a 'good' and 'bad' performance for all indicators, and often 'OK' and 'poor' performance as well. This can be a challenging and thought-provoking task, and may take a good deal of discussion. Naturally, making judgements is necessary throughout any assessment, from formulating a vision to choosing indicators. All of this is beneficial. Discussing key elements and their indicators, and deciding on desirable and unacceptable performance for each indicator, is essential for building consensus on the nature and relationship of human and ecosystem wellbeing.

Several performance scales have been devised. Sustainability Assessment uses the Barometer of Sustainability (Figure 8) because it is the only performance scale designed to measure human and ecosystem wellbeing together and without elevating the importance of one above that of the other.

The Barometer's 0-100 scale is divided into five bands of 20 points each. The bands correspond to performance criteria defined for each indicator, and are therefore a clear and direct method of controlling how scores are distributed. By defining as precisely as possible what each of the Barometer's bands represents, assessment users will avoid unnecessary confusion.

Box 4: Common Units

'Common units' are either physical units or monetary units. Physical units are appropriate for a limited range of elements. Materials can be combined on the basis of their weight, but this does not account for the different impacts of materials. Pollutants with similar effects can be combined according to their potential for that effect—such as global warming, ozone depletion, acidification, or toxicity—but pollutants with different effects cannot be combined in this way. Uses of energy and renewable resources can be converted into the area of productive land and sea required to supply the resources and absorb carbon dioxide from fossil fuels but area is not a suitable unit for measuring air quality or genetic diversity (Adriaanse 1993; Weight: Adriaanse et al 1997; Area and Ecological Footprint Wackernagel and Rees 1996, Wackernagel et al 1997). No single physical unit has been found that could combine all indicators of ecosystem wellbeing, let alone of human wellbeing.

'Money' is standard in all economic accounts, from the System of National Accounts to Genuine Saving and the Genuine Progress Indicator. It is also used in some environmental assessments, such as the cost of remediation (COR) index, a measure of the cost of moving from the present state of the environment to a more desirable level sometime in the future (Harvard University 1996). However, money has serious weaknesses as a common unit. It reflects the market price of things, like apples and oranges, but not their taste, nutritional content, or cultural value. It can measure the value of things that are traded in the market but it distorts the value of anything that is not traded. The less tradable the item, the greater the distortion created when working with 'money' as the common unit.

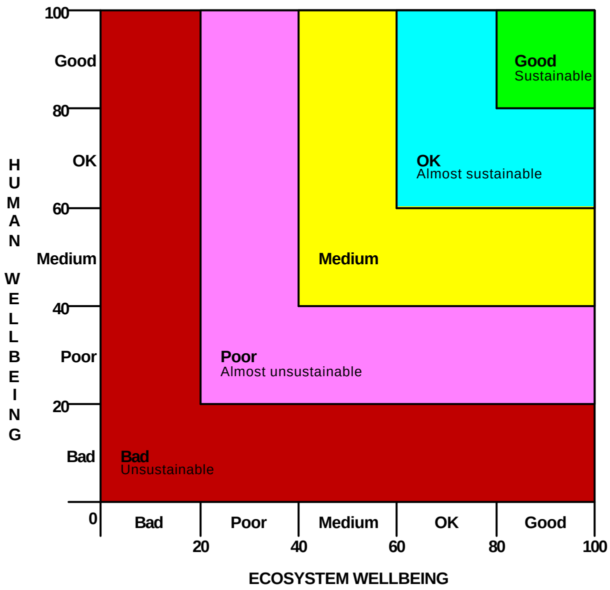

Figure 8: The Barometer of Sustainability

Deciding performance criteria involves defining the top of each band and the base of the scale. This is a matter of judgement by the participants of a Sustainability Assessment and is done on the basis of the following standards:

1. The range of recent, current and expected performance of that issue/indicator.
2. The objective of the issue concerned. For example, if the objective of your health issue is a "long and healthy life", and you pick 'life expectancy' as the indicator, then you will need to specify a 'good' band with a high score (80 years or higher!).
3. At least one of the following:
   A. Estimated sustainable rate. For example, a sustainable rate of timber felling would be less than 100% of net annual increment.
   B. Estimated background rate ('natural' or 'normal' performance). For example, the background rate of animal extinctions is estimated to be less than 0.01% of species per century. A desirable percentage of threatened species could be defined as not more than 100 times that rate.
   C. Other threshold. For example, countries have increasing difficulty supporting external debt when debt service payments are above 20% of exports of goods and services.
   D. International (or national) standard. For example, a UN standard for water quality is under 30 milligrams of nitrogen per litre of water.
   E. International (or national) target. For example, a UN target for education is 100% primary education by 2015.
   F. Expert opinion.
   G. Match of a closely linked or related indicator. For example, there is no specific UN target for adult literacy, but it would be logical for the performance criteria for literacy to match those for primary education.

H. Derivation from a closely linked or related indicator. For example, there is no specific UN target, the performance criteria for secondary education are a less stringent version of those for primary education.

I. The judgement of participants. If none of the above factors is available, the choice of performance criteria is entirely up to the judgement of participants.

The three steps above must be carried out for each indicator. Selecting which of the standards, A— I, to follow will depend on various circumstances. Check which of the standards exist and which is most likely to be most accurate: A to C are scientific standards, D and E are consensus-based and F to I are more judgement-based. A descriptive narrative will help explain your choice of standards for determining performance criteria for each indicator.

The 'good' band defines *most desirable* performance as: performance that represents full achievement of the objective. Lower bands on the Barometer define the variation from this 'good' ideal. As such, performance criteria are *not* targets, which balance what is desirable and what is achievable. Target setting is a separate activity. Targets are part of planning the necessary steps to move from the present situation toward eventual attainment of the objective. Targets are highly specific to the conditions of each society. A society whose performance is in the medium band will probably set targets to get into the OK band, and then into the good band. A society whose performance is in the bad band (or below) is likely to aim for the poor band and then for the medium band.

As an example, Table 5 shows illustrative performance criteria for the indicator 'threatened species in a group as a percentage of total species in that group.'

Table 5. Performance criteria for the indicator 'threatened animal species in a group as a percentage of total animal species in that group' (based on: mammals, birds, amphibians, reptiles)

Band	Top point on scale	Threatened animal species in a group as % of total animal species in that group
good	100	0
OK	80	2
medium	60	4
poor	40	8
bad	20	16
base	0	32

These performance criteria have emerged from the process of thinking about the standards for setting performance criteria, as listed above. To start with, the performance range for countries spans from 0% (Malta) to 72% (Réunion). The objective is to reduce species loss to a minimum. The background rate (standard 'B' above) of animal extinctions is estimated to be less than 0.01% of species per century. It is assumed that the background percentage of threatened species is less than 100 times the extinction rate, or less than 1%. Therefore, best (the top point of good) is set at 0%, and the top of OK is set at 2%. The tops of the remaining bands rise exponentially[1] to 32% (the base of the scale), at which point the scale is truncated to prevent undue distortion. The exponential rise from 0% to 32% reflects the fact as the percentage of threatened species moves closer to 0%, the harder it is to improve performance.

It is not easy to determine the best way of distributing rates of change for a specific indicator across the performance bands. To be able to establish the 'jump' between the top points of the scale, it is necessary to determine whether performance criteria for an indicator increases or declines exponentially. An indicator requires an exponential performance scale if it is increasingly difficult to improve performance as one approaches the ideal. An example is the threatened species indicator in Table 5. In this table, the bands are not equi-distant, instead jumping from 32% to 16, 8, 4 and finally 2% before reaching the ideal of 0% threatened animal species. For other indicators it makes sense for the performance criteria to increase or decline exponentially from the *worst* point, to reflect diminishing returns: for example, 'income per person.'

Understanding the five categories of indicators can provide a starting point for making a good decision about how to distribute any indicator's rate of change across the bands of the Barometer:

1. ***Best possible performance is 0, 0%, 100%, or parity***. For example, homicide rate (0), infant mortality rate (0%), population with safe water and basic sanitation (100%), female share of earned income (parity). It is critical that the properties of the upper part are correct. What needs to be decided here, is how far 'good' is from 'best possible,' and how far 'OK' is from 'good.'
2. ***No limit to best possible performance.*** But, the worst possible performance is 0, 0% or 100%. For example: 'income' ($0). It is also critical that the lower part of the performance scale that is correct. What needs to be decided here is how far from 'worst possible' does 'bad' performance become 'poor' performance.
3. ***A sustainable level can be defined as, a level on both sides of which conditions are unsustainable***. For example, total fertility rate (TFR), is the average number of children born alive by a woman in her lifetime. In this case, the sustainable rate is the replacement rate, or 2.1 (with average sex ratios). Populations will grow if their TFRs are above this rate, and will decline if they are below it. A performance scale must be formulated that will put TFRs of, for example, either 2.6 or 1.6 into the band of poor performance. The rates on both sides of the sustainable level need to be decided. For example, deciding the jump between 'good' and 'OK' for rates that are higher than sustainable and rates that are lower than sustainable.
4. ***A sustainable level can be defined, on only one side of which conditions are unsustainable***. For example, timber fellings as percentage of net annual increment. In this case, the sustainable rate is 100% (only felling what is added each year) or (using the precautionary principle[2]) less than 100%. If fellings are much less than 100% no harm is done because the forest will eventually reach a

[1] Exponential refers to rates of change that increase. They are non-linear, i.e. do not show the same amount of change over the same period of time.
[2] Using the precautionary principle, which states that if we are unclear about the consequences of environmental damage, decisions should err on the side of caution.

natural state with a high proportion of old trees. Identify the sustainable rate, and then decide how far from that rate is ‘OK,’ ‘medium,’ and so on.

A range of good or bad performance can be broadly defined, but a concrete best possible, worst possible or sustainable level cannot. For example, ‘energy consumption per person,’ about which there is no clear consensus yet. In this example, assessment participants need to decide what level of energy consumption is acceptable for the context being assessed, given the local availability of energy. This is a matter of judgement.

Narrative and Performance Criteria

Narrative is particularly important at this stage of Sustainability Assessment, as the complexity and judgement-value based nature of selecting indicators and performance criteria may be difficult for others to understand. Participants themselves may need to refer to this part of the narrative regularly to remind themselves of the basis of their choices.

It is useful to also document the process of selecting indicators and performance critieria, particularly how the decisions were made, what compromises (if any) were observed, and to which general criteria (refer to above) the final decision used.

STAGE 4. MEASURE AND MAP INDICATORS

Stage	Narrative	Measurement	Mapping
4. Measure and map indicators	Draw attention to main findings and explain apparent anomalies.	Measure the indicators and calculate their scores.	Map the indicators.

Having chosen the indicators and identified what data is required, it is necessary to obtain the data for them. As part of the assessment, the team needs to create a database and to make arrangements with sources of existing data to receive them regularly. Monitoring systems and surveys will need to be organised for any indicators requiring data not currently collected. All data will need to be entered into the database, which should be geographically referenced.

Much of this step is of a highly technical nature, and is located in ***Technical Note Using Performance Indicators***. This is a step that would normally be undertaken by the assessment’s technical team in charge of maintaining the database, calculating and combining indicators and creating maps.

Map Indicators and Explain Findings

Each indicator score will reflect the strengths and weaknesses of the indicator, the quality of the data, and the judgements and interpretations of participants in the assessment. It is important to highlight the main findings, and to discuss how they are influenced by these and other factors. Maps will be an invaluable aid in helping analysis.

All ecosystem indicators and most human indicators can be represented spatially. Therefore maps are a highly effective way of recording, analysing and communicating how indicators vary over a spatial area. Maps aid analysis by revealing patterns of performance and links among indicators. Moreover, although information can be recorded in other ways (tables, databases, etc.), the mapping of indicators is an essential part of this method because it:

- forces participants in the assessment to tie the work to a real and specific place or situation;
- obliges participants to gather information about the whole area, rather than a few locations, which is essential to avoid generalisations from a small number of experiences;
- highlights data gaps;
- exposes data trends and peculiarities, which then may be explored in greater depth, for example through statistical analysis;
- facilitates comparison among different situations, sites, and times;
- allows immediate consultation of the underlying data whenever necessary, using software (notably Map Maker Pro) that links maps and databases;
- is a powerful communication tool, as many people, especially villagers, understand the visual aspect of maps better than written tables or text.

Be Careful! Like any communication tool, maps can be misleading. Maps can imply accuracy of detail when the data is based on estimates. Maps can also obscure or generalise information, portraying all streams or waterways as rivers. Or the absence of features may imply they do not exist, when it may be the data does not exist or they have been intentionally left out.

These misunderstandings can be avoided to some extent by considering whether the scale, projection, symbols, labels, colours, shading or other features of the maps are likely to be misinterpreted. Even more important than accurate map detail, is ensuring that a narrative accompanies the indicators, which offers an analysis of their strengths, weaknesses and implications. Such explanations of the quality of each indicator will allow users to form their own opinion about the value of the information that they see on the map.

STAGE 5. COMBINE THE INDICATORS INTO INDICES

Stage	Narrative	Measurement	Mapping
Stage 5: Combine indicators and map indices	Draw attention to main findings and explain apparent anomalies.	Combine the indicators into indices.	Map the indices.

Once indicators have been given a score they can be combined. As indicator scores are calculated in the same way using the same five band scale, the scores can be combined into indices, or compound indicators. These scores can be combined throughout the hierarchy of elements. Indicators are combined into a sub-issue index, or an issue index, if there is no sub-issue. Sub-elements are combined into an issue index, elements into a dimension index, and dimensions into a subsystem index.

There is a subsystem index for people, the Human Wellbeing Index (HWI), and another for the ecosystem, the Ecosystem Wellbeing Index (EWI).

Again, this exercise is of a more technical nature, and is give a full explanation in Technical Note on Using Performance Indicators.

Map indices and explain results

As with the indicators, a map is generated for each index by linking the base map to the appropriate set of scores, so that the pattern of performance at the differentiation level is shown.

Like the indicator results, each index will reflect the strengths and weaknesses of its constituent indicators, the quality of the data, and the judgements and interpretations of participants in the assessment—including their decisions about combining procedures. In addition, the dimension indices and especially the Human Wellbeing Index, Ecosystem Wellbeing Index and Wellbeing/Stress Index will give interesting and perhaps surprising results, simply because they combine a much wider range of elements than people are used to considering together. It is important to point out the main findings, and to discuss how they are influenced by these and other factors.

STAGE 6: REVIEW RESULTS AND ASSESS IMPLICATIONS

Stage	Narrative	Measurement	Mapping
6. Review results and propose policies.	Analyse performance, discuss causes and implications, and propose policies and actions.	No activity.	No activity.

The effectiveness of the Sustainability Assessment is determined by what actions are planned and taken in response to it. Eventually, the assessment's effectiveness will be measured by the difference those actions make to people's lives and the condition of the ecosystem. Thus far, the assessment process has produced indicators and indices that show existing conditions in terms of how far the actual situation is removed from the ideal, system goal or vision. This is, of course, only a snapshot. What remains is bridging the gap between current situation and future vision. Reviewing the collected data is the critical link that transforms the assessment into action.

The questions and ideas below are offered as a start to the analysis. Realistically, the results of Sustainability Assessments are an input to other processes. These questions, then, should be the start of an analysis-action process, rather than its defining product.

Reviewing requires:

- analysing the indicators and indices, the patterns of performance that they produce, and the data behind them;
- determining the elements and areas where improvements are most needed;

- proposing policies and actions to realise the improvements, including reviewing and revising policy, programme and project objectives and targets.

Analysis runs through these tasks and involves answering the following questions:
- What's going well? What's going poorly?
- Why? What are the causes?
- What are we doing about it? What should we do?
- What are the consequences of doing it/not doing it?
- What are the obstacles to doing it?
- What knowledge do we lack about what to do or how to do it?
- What conflicting interests exist within society?
- What external forces (such as trade barriers) are at play?
- Does what we are trying to do conflict with other objectives?
- Do we have sufficient resources?
- How can the obstacles be overcome?

What do the numbers and maps that emerge mean in relation to action priorities? Participants of a Sustainability Assessment need to be able to draw conclusions from the numbers and visuals that can lead to identifying priorities for improvement. The indicators and maps only take on meaning when their 'patterns of performance' are analysed. This happens at various levels:

- Comparing performance of different dimensions and elements using the Barometer of Sustainability, for example how the health dimension compares to wealth dimensions.
- Comparing current to future desired state, for example, how far removed is current land quality from the ideal—and to what extent is that a critical bottleneck for sustainable development;
- Comparing indicator-related performance across different units, such as how neighbouring communities or countries perform in relation to each other;
- Exploring relationships among elements, such as: consumption, human wellbeing and ecosystem stress; human benefits and ecosystem stress from different economic sectors; and food sufficiency, income levels, income distribution, land degradation, agricultural productivity and food self-reliance.

Questions and processes are critical for analysis to be productive. Questions act as a `filter' through which many ideas and fragments of information are funneled and consolidated. In past assessments, questions that have helped to analyse indicators in terms of their 'patterns of performance' include:

1. Which dimensions are holding back progress towards sustainability most (refer to the Barometer of Sustainability), and which issue(s) within the poorest performing dimension(s) appear to be the bottleneck?
2. Which indicators show acceptable levels of system performance, and which ones point to a problem area?
3. How do 'bottleneck elements/dimensions' vary from one unit of the differentiation level to another (i.e. across communities, districts, countries, etc)? And therefore, what variation will there be in where priorities are likely to lie?

Which elements, and their indicators, seem to be related? For example, do two elements in one dimension seem to perform equally poorly or surprisingly differently?

A Final Note on Assessments

Assessments are processes of diagnosis, monitoring, analysis and evaluation. They are done by *organizations* (alone or jointly) whose purpose is to influence a particular *system* (human society and its surrounding and supporting ecosystem) through specific activities, referred to generically as *projects*. Each of these elements (organization, system, project) requires an assessment method suited to its own characteristics and needs, thus defining three types of assessment. Environmental impact assessment is a fourth type.

Types of assessment

System assessment: assessment of a human society and economy and the ecosystem that surrounds and supports them. The function of system assessment is to show the conditions and trends of people and the ecosystem, the impacts of human activities on both, which activities most need changing and in what ways. **Full system assessments** review all or most of the issues that are considered to be key for human and ecosystem wellbeing. **Thematic or sectoral assessments** cover the issues that are considered to be most relevant to the theme or sector concerned.

Organizational assessment: exploration of an organization's mission and operations and the factors that enhance or hinder them. Its function is to enable the organization to review its role, capacities, achievements and shortcomings, and so improve its impact on the system. **Organizational self-assessment** is undertaken by the organization itself. **External organizational assessment** is done by others.

Project assessment: evaluation of a specific activity and its results. Its function is to assess the relevance and impact of the activity in relation to the system and to the organization's mission. It also evaluates the efficiency and effectiveness of the activity. **Project self-assessment** is carried out by the group undertaking the activity. **External project assessment** is done by an outside agency.

Environmental impact assessment: analysis of the expected impacts of a proposed policy, programme or project on the ecosystem and society Its function is to evaluate the foreseeable effects of proposed projects and policy options, with the aim of avoiding or minimizing harm and optimizing benefits.

The Biodiversity Assessment method described in this guide is a form of system assessment. It is suitable for use nationally, internationally, or locally. It can be used for thematic assessments of biodiversity, for reporting on the CBD, as part of full assessments of sustainable development, and as a framework for organizational, project, and environmental impact assessments.

Technical Note: Using Performance Indicators

This section is intended for readers who are primarily interested in developing performance indicators that can be combined into indices of sustainability. This is a technical annex, designed to cover the issues related to scaling indicators, calculating indicator scores and combining indicators into indices.

This Technical Annex is also suitable for those undertaking a full Sustainability Assessment, as it contains all of the technical information on performance indicators required to complete the process.

When working with indicators, as part of reporting for the Convention of Biological Diversity or as part of a full Sustainability Assessment, it is most helpful to compile a meta-database – a source of information about data. The first section of this annex addresses those issues.

Compile a meta-database

A meta-database provides information on the availability of data. This meta-database is compiled from answers to questions, on each issue, about data collection, storage and access and information products. These questions are asked for each issue:

Data collection

- What? What is measured? In what units? What are the standards for precision and accuracy?
- Where? What are the spatial units? Where are they? Are the spatial units mapped? If so, are the maps paper or digital or both? If digital in what format?
- How? What is the means of data collection?
- When? What are the temporal units? When are the measurements taken? How often?
- Who? Who is responsible for collecting the data?

Data storage

- What? Are the data stored in raw form (as collected) or processed or both? If processed, in what ways?
- Where is the data stored?
- How? Paper or electronic database or both? If electronic in what format?
- Who? Who is responsible for storing the data?

Data access

- How? How can the data be obtained? What restrictions are there (if any)? What charges are there (if any)?
- Who? Who is responsible for providing access to the data?

Information products

- What? What information products are produced from the data (usually by the organisation responsible for data storage or data access)?
- When? Are the information products produced regularly or occasionally? If regularly, when?
- Who? Who produces the information products?

Most of the indicator initiatives in the world proceed as though data is always easy and inexpensive to obtain, without ever analysing this belief. Creating a meta-database will provide most of the information to be able to analyse data requirements for each issue at the indicator stage (see Section 6). This database will also be very useful after indicators have been drafted, to assess whether data exists and whether or not these indicators are feasible.

1. What statistics are compiled regularly for the chosen spatial level, at what intervals, the topics they cover, and where they are held?
2. What statistics are compiled occasionally, when, the topics they cover, and where they are held?
3. What other data are available in electronic databases and published reports, the topics they cover, and how they can be obtained?
4. What data are available in unpublished reports and files, the topics they cover, how they can be obtained, and how big a task it would be to get useful information from them?
5. What other information sources exist, such as expert groups or key individuals (elders, healers, traditional leaders)?

Measure and Map Indicators

This section supplies the technical information required to use performance scales to calculate indicator scores. In simple terms, each indicator, using the performance scale, can be converted from its native units to a 0 – 100 scale, thus allowing them to be easily compared and combined.

Measure indicators and Calculate Scores

Once the data have been obtained for an indicator, the measurements are given scores on the basis of the performance criteria. The performance criteria define the bands, while the indicator score will determine in which band a given indicator measurement will fall. For example, using the criteria given below, a life expectancy at birth of 55 years goes into the poor band because it is between 60 years (the top of the poor band) and 45 years (the top of the bad band). Using the criteria in Table 6.4, if 3% of animal species are threatened, that result goes into the OK band, because it is between 2% (the top of the OK band) and 4% (the top of the medium band).

Band	Top point on scale	Life expectancy at birth (years)
good	100	85
OK	80	75
medium	60	70
poor	40	60
bad	20	45
base	0	25

The indicator measurement's exact position in the band is determined by calculating its score. There are two ways to determine the band position, depending on whether:

- 'best performance' is the maximum value and 'worst performance' is the minimum value. For example, life expectancy at birth.

Or:

- 'best performance' is the minimum value and 'worst performance' is the maximum value. For example, threatened animal species as a percentage of total animal species.

When 'best' is the maximum value and worst is the minimum, the indicator score is calculated as follows:

> ([actual minus minimum] divided by [maximum minus minimum])
> multiplied by 20, then added to the base of the band.

For example, the life expectancy at birth of a Zimbabwean born in 1995 was 50.7 years. This would place , putting it in the 'poor' band. The calculation is:

> 50.7 (actual) – 45 (minimum) = 5.7
> 60 (maximum) – 45 (minimum) = 15
> 5.7 ÷ 15 = 0.38
> 0.38 × 20 = 7.6
> 7.6 + 20 (base of band) = 27.6 = **28**

Scores are rounded to the nearest whole number. A score of 0.5 may be rounded down or up. The score is usually rounded conservatively, whichever produces the lower score.

Note that the base of a band is the top of the band below. When best is the maximum value and worst is the minimum, the maximum value corresponds to the top of the band, and the minimum value corresponds to the base of the band (Table 6).

Table 6. Tops and bases of bands and corresponding maximum and minimum values when best performance is the maximum value and worst performance is the minimum value

Band	Points on scale	Top of band =	Base of band =	Maximum value corresponds to:	Minimum value corresponds to:
Good	100-81	100	80	100	80
OK	80-61	80	60	80	60
Medium	60-41	60	40	60	40
Poor	40-21	40	20	40	20
Bad	20-1	20	0	20	0

When *best is the minimum value and worst is the maximum*, the indicator score is calculated as follows:

> ([actual minus minimum] divided by [maximum minus minimum]) multiplied by 20, then subtracted from the top of the band.

For example, the mean percentage of threatened animals in Venezuela is 3.8%, putting it in the OK band. The calculation is:

3.8 (actual) – 2.0 (minimum) = 1.8
4.0 (maximum) – 2.0 (minimum) = 2.0
1.8 ÷ 2.0 = 0.9
0.9 × 20 = 18
80 (top of band) – 18 = **62**

Note that when 'best' is the minimum value and 'worst' is the maximum, the *minimum* value corresponds to the top of the band, and the *maximum* value corresponds to the base of the band. (Table 7).

Table 7. Tops and bases of bands and corresponding maximum and minimum values when best performance is the minimum value and worst performance is the maximum value

Band	Points on scale	Top of band =	Base of band =	Maximum value corresponds to:	Minimum value corresponds to:
Good	100-81	100	80	80	100
OK	80-61	80	60	60	80
Medium	60-41	60	40	40	60
Poor	40-21	40	20	20	40
Bad	20-1	20	0	0	20

Combine Indicators into Indices

This section covers issues related to combining and weighting indicators.

Indicators, sub-elements, elements, or dimensions) are combined in one of three ways:

- ***Unweighted average:*** the elements are added and averaged. For example, if one element has a score of 70 and another has a score of 30, the combined score is 50: $70 + 30 = 100 \div 2 = 50$.
- ***Weighted average:*** the elements are given different weights, and then added and averaged. For example, if the element with the 70 score is given a weight of 1, and the element with the 30 score is given a weight of 2, then the combined score is 43: $(70 \times 1) + (30 \times 2) = 130 \div 3 = 43.3$. (Scores are multiplied by their weights and then the total score is divided by the total weight. In this case a weight of 1 plus a weight of 2 makes a total weight of 3.)
- ***Veto:*** a lower score overrides a higher score. For example, the element with the 30 score would override the element with the 70 score, giving a combined score of 30.

An *unweighted average* is used to combine elements that are considered to be roughly equal in importance or in the quality and coverage of the indicators and to offset each other. Note that good performance in one element can offset bad performance in another element. For example, in a district assessment, within the issue of 'water,' two indicators of 'water quality' and 'water quantity' may be considered equally significant in terms of determining the overall water situation. These two indicators contribute equally to the overall state of 'water' and are not weighted. An unweighted average is also used when it is felt to provide a more representative picture than if a veto were used. For example, the human wellbeing index and the ecosystem wellbeing index are *always* the unweighted averages of their constituent dimensions.

A *weighted average* is used to combine elements that are considered to be unequal in importance or in the quality and coverage of the indicators. The weight reflects the difference in importance or in quality and coverage. For example, the index of species diversity could be given twice the weight of the index of population diversity (both within the dimension of 'species and populations') because the loss of a species is more significant than the loss of a population or genetic line.

A *veto* is used to combine elements that are considered to be roughly equal in importance, but not to offset each other.

Averaging assumes that good performance in one dimension compensates for bad performance in the other, and vice versa. If it does not, it is assumed that the average conveys a truer sense of the dimension than would the lower score. Using the lower score implies that wellbeing requires good performance in both issues. For example, Ireland's scores for land diversity and land quality are 29 and 96 respectively. If the good score for land quality offset the poor score for land diversity, then taking the average (62) would be justified. But land diversity measures the conversion and modification of all land ecosystems, whereas land quality measures the degradation primarily of cultivated

The Wellbeing Index and the Wellbeing/Stress Index

The Wellbeing Index (WI) can be expressed numerically as the lower portion of the Human Wellbeing Index (HWI) and the Ecosystem Wellbeing Index (EWI). However, the representation of the Barometer of Sustainability is more informative because it illustrates graphically the relationship between the HWI and the EWI. This relationship can hardly be captured when it is expressed as a single number.

The Wellbeing/Stress Index (WSI)—the ratio of human wellbeing to ecosystem stress—is produced in two steps. First, the Ecosystem Wellbeing Index score is subtracted from 100 to convert it into an Ecosystem Stress Index. In the next step the Human Wellbeing Index is divided by the Ecosystem Stress Index. The performance criteria adopted by *The Wellbeing of Nations* for the WSI are shown in Table 8. A WSI of 1.0 means that ecosystem stress equals human wellbeing, and a WSI below 1.0 means the ecosystem stress exceeds human wellbeing.
In the case of Mauritius (Table 9).

- 100 – 47 = 53 (Ecosystem Stress Index)
- 59/53 = 1.11 (Wellbeing/Stress Index).

In the case of Comoros, the situation is dramatically different. Comoros has a lower ecosystem stress index but also a much lower sustainability index due to the very low level of human system sustainability:

- 100 – 42 = 58 (Ecosystem Stress Index)
- 24/58 = 0.41 (Wellbeing/Stress Index).

Table 8: Performance criteria for the Wellbeing/Stress Index (Prescott-Allen, in press)

Band	Top point on scale	Ratio of human wellbeing to ecosystem stress
Good	100	8.0
OK	80	4.0
Medium	60	2.0
Poor	40	1.0
Bad	20	0.5
Base	0	0

Table 9: Southern African scores for human wellbeing, ecosystem stress, and progress toward sustainability index (human wellbeing per unit of ecosystem stress) (Prescott-Allen, in press)

Country	Human wellbeing	Ecosystem stress	Human wellbeing/ ecosystem stress
Mauritius	59	53	1.11
Botswana	37	35	1.06
Namibia	35	35	1.00
Malawi	27	27	1.00
Zimbabwe	27	36	0.75
Zambia	26	38	0.68
Madagascar	29	44	0.66
South Africa	39	60	0.65
Swaziland	27	42	0.64
Mozambique	20	33	0.61
Lesotho	22	44	0.50
Angola	15	31	0.48
Comoros	24	58	0.41