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Biodiversity assessment

Biodiversity assessment framework: making biodiversity part of corporate social responsibility

Roel Slootweg

A multitude of tools and techniques exists to predict, measure or report on human impacts on the environment. Biodiversity is receiving increased attention but in many cases it is not clear what interpretation of 'biodiversity' these instruments are based on. The Convention on Biological Diversity provides definitions and supporting documents on what biodiversity is. The Biodiversity Assessment Framework is based on these principles and provides an all-encompassing analytical framework to identify the potential biodiversity impacts of any human activity. It is developed as a reference for the private sector to appraise its tools and procedures from a biodiversity perspective. The framework presented is generic and needs further translation into practical instruments, geared toward specific tasks or situations. In this respect it is intended to be used in a broader context than impact assessment.

Keywords: biodiversity; corporate social responsibility; Convention on Biological Diversity; ecosystem approach

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BIODIVERSITY ENCOMPASSES all living organisms on earth, their interactions, and the interaction with the physical environment (soil, water, air). Human beings can be considered to be part of biodiversity since they are living creatures, in continuous interaction with the environment, and dependent on biodiversity for their survival.

Biodiversity produces the oxygen we breathe, regulates water supplies, sequestrates greenhouse gases and thus is responsible for regulating climate, provides food, such as fish, shellfish, and (bush)meat, and also provides products, such as timber or raw materials for pharmaceutical industries, constitutes a source of genetic material of use to maintain the long-term productivity of our agricultural crops (themselves also being part of biodiversity), is a source of inspiration, recreation and greatly contributes to the quality of our day-to-day lives. These examples are given to illustrate that human existence is impossible without biodiversity and to show that biodiversity is not a complicated concept but a visible reality surrounding and supporting us.

In spite of this, mankind has treated biodiversity rather carelessly over recent centuries as a result of unsustainable exploitation of natural resources and an exploding world population. Scientific observations teach us that diversity contributes to stability and buffering; a loss of diversity consequently leads to more unstable ecosystems that are more easily pushed out of balance. Life support processes become less reliable. The rapid loss of biodiversity has received increased attention and, in recent years, a number of guiding principles have been formulated that define the way in which we should deal with biodiversity. Two important principles are:

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- The principle of ‘no net loss’ of biodiversity. Any further decline in biodiversity should be considered negative or undesirable. New human activities should not lead to further decline of biodiversity.
- The precautionary principle. There are many unknowns about the processes that influence biodiversity, particularly at ecosystem level. In areas with high biodiversity value only activities with limited or no impact on biodiversity should be allowed to be carried out. If impacts cannot be established with sufficient certainty, the activity should be halted as a precaution until enough information is available.

The application of these principles is seriously hampered by the lack of an instrument to define human impacts on biodiversity based on a clear and comprehensive interpretation of the term ‘biodiversity’.

A multitude of tools and techniques are currently used by companies, certifying agencies and the like, to predict, measure, or report on human impacts on biodiversity. Examples are environmental impact assessment, audits, sustainability reporting and certification. These instruments are not always based on an unambiguous interpretation of biodiversity. As the Convention on Biological Diversity (CBD)[1] has provided clear definitions and supporting documents on what biodiversity is, it should be possible to judge whether the above-mentioned instruments comply with the terms of the convention.

This was the reason the Netherlands Ministry of Environment started the ‘Biodiversity Assessment Framework’ project. Its objective was to formulate a general assessment framework that provides an all-encompassing analytical framework to identify the potential biodiversity impacts of any imaginable human activity. The framework starts from the CBD objectives and uses the ecosystem approach as a conceptual ‘umbrella’ (see Box 1 and CBD, 1999). Scientific concepts on evaluation of functions provided by biodiversity were derived from publications leading up to the recent CBD guidelines on integration of biodiversity in impacts assessment (CBD, 2002).

Box 1. The ecosystem approach (as adopted by the 187 parties of the Convention on Biological Diversity, by Decision 6 at the 5th Conference of Parties)

The ecosystem approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. An ecosystem approach is focused on levels of biological organisation, which encompasses the essential processes, functions and interactions among organisms and their environment. It recognises that humans, with their cultural diversity, are an integral component of ecosystems.

The definition of ecosystem does not specify any particular spatial unit or scale, but can refer to any functioning unit at any scale. Indeed, the scale of analysis and action should be determined by the problem being addressed. The ecosystem approach requires adaptive management to deal with the complex and dynamic nature of ecosystems and the absence of complete knowledge or understanding of their functioning. Adaptive management must be able to respond to such uncertainties and contain elements of ‘learning by doing’. As with the precautionary principle, measures may need to be taken even when some cause–effect relationships are not fully established scientifically.

Principles of the ecosystem approach:

1. The objectives of management of land, water and living resources are a matter of societal choice.
2. Management should be decentralised to the lowest appropriate level.
3. Ecosystem managers should consider the effects (actual or potential) of their activities on adjacent and other ecosystems.
4. Recognising potential gains from management there is a need to understand the ecosystem in an economic context. Any ecosystem management programme should a) reduce those market distortions that adversely affect biological diversity; (b) align incentives to promote biodiversity conservation and sustainable uses; and (c) internalise costs and benefits in the given ecosystem to the extent feasible.
5. A key feature of the ecosystem approach includes conservation of ecosystem structure and functioning.
6. Ecosystems must be managed within the limits of their functioning.
7. The ecosystem approach should be undertaken at the appropriate scales.
8. Recognising the varying temporal scales and lag-effects that characterise ecosystem processes, objectives for ecosystem management should be set for the long term.
9. Management should recognise that change is inevitable.
10. The ecosystem approach should seek the appropriate balance between conservation and use of biological diversity.
11. The ecosystem approach should consider all forms of relevant information, including scientific and indigenous and local knowledge, innovations and practices.
12. The ecosystem approach should involve all relevant sectors of society and scientific disciplines.

Operational guidance for application of the ecosystem approach:

1. Focus on the functions of (biodiversity in) ecosystems.
2. Promote the fair and equitable sharing of the benefits derived from the functions of (biological diversity in) ecosystems.
3. Use adaptive management practices.
4. Carry out management practices at the scale appropriate for the issue being addressed, with decentralisation to lowest level as appropriate.
5. Ensure inter-sectoral co-operation.

Source: Convention on Biological Diversity: Decision V/6 Ecosystem Approach, (<http://www.biodiv.org/decisions/default.aspx?m=COP-05&id=7148&lg=0>, last accessed 7 February 2005) and Decision VII/11 Ecosystem Approach (<http://www.biodiv.org/decisions/default.aspx?m=COP-07&id=7748&lg=0>, last accessed 7 February 2005)

Slootweg *et al* (2001) provide an integration framework providing impact pathways through social and biophysical changes processes caused by human interventions. In IAIA (2001), this approach was detailed for biological diversity, providing a way to identify the impacts on biodiversity itself as well as the societal consequences of these effects (a shortened version was recently published as Slootweg and Kolhoff, 2003).

The assessment framework describes nine principles and 11 analytical steps for the analysis of biodiversity impacts of human activities. The principles generally apply to any analysis and have to be kept in mind with each step of an analysis. The 11 analytical steps provide an iterative way of thinking; they should not be read as a rigid procedure. It is important to realise that the assessment framework is not intended to replace existing instruments with a new instrument; it merely creates a framework to appraise existing instruments on biodiversity-related aspects. The framework also provides the background to develop new biodiversity assessment instruments.

The target audience is specialists responsible for the development of sector- or company-specific instruments who need guidance on how to integrate biodiversity into them. These instruments include impact assessment, but may also be related to sustainability reporting or certification of products, life-cycle analysis, and so on.

General principles

Throughout the following text, the links with the principles and operational guidance provided by the ecosystem approach (ES) (CBD, 1999; 2004) will be indicated in brackets.

A. Biological diversity: the challenge posed by the Convention The CBD requires parties to formulate and implement policies for the protection of:

- Ecosystems containing (i) rich biodiversity; (ii) large numbers of threatened or endemic species, with social, economic, cultural or scientific significance; or (iii) relevant for key processes such as evolutionary ones; and (iv) ecosystems of relevance to migrating species;
- Species and communities of species that are (i) threatened in their existence; (ii) related to domesticated or cultivated species; and (iii) species with medicinal, agricultural, or other economic, social, cultural or scientific significance; and (iv) indicator species;
- Genotypes with social, scientific or economic significance.

The assessment framework is not intended to replace existing instruments with a new instrument; it merely creates a framework to appraise existing instruments on biodiversity-related aspects and a background to develop new biodiversity assessment instruments

Each contracting party to the Convention must, as far as possible and as appropriate, identify components of biological diversity important for its conservation and sustainable use, and identify processes and categories of activities that are likely to have significant adverse impacts on the conservation and sustainable use of biological diversity, and monitor their effects.

B. Conservation, sustainable use, and fair and equitable sharing of benefits The 187 parties to the Convention have agreed on the triple objective:

- the conservation of biological diversity;
- the sustainable use of its components; and
- the fair and equitable sharing of the benefits arising out of the utilisation of biodiversity.

By creating a transparent and participative procedure, the biodiversity assessment framework aims to provide relevant stakeholders with the opportunity to express their views.

C. Functions of biodiversity: products and services (ES Principle 6 and operational guidance).

The living environment (biodiversity) provides goods and services of importance for human society. Examples of such goods and services, also referred to as functions of biodiversity,[2] are:

- Harvestable goods, such as fish, timber, bush meat, fruits, genetic material — often referred to as production functions. Agriculture, fish farming and plantations are examples of production functions that need additional human inputs.
- Safeguarding certain areas against forces of nature, such as coastal protection by mangroves; maintenance of processes such as climate regulation, or regulation of water runoff; natural purification of water; maintenance of biodiversity itself — regulation functions.
- Suitability of areas for certain activities such as dwellings, recreational activities, nature conservation — carrying functions.
- Biodiversity is a source of spiritual, religious, recreational or scientific 'information' — signification functions. For example, a large proportion of the tourism industry depends on this biodiversity service.

Ecosystems are by definition multifunctional — an area can provide more than one good or service simultaneously. For example, a forest provides timber and other forest products, maintains populations of birds and invertebrates, is being used for recreational purposes, is an important regulator for rainwater storage and runoff, and protects the soil against erosion. Forest management may be set to maximisation of one function (for example, timber production) or a combination of functions (for example, less intensive timber production in order to maintain a bio-diverse forest, interesting for hikers, with minimal soil erosion and optimal water regulation for the protection of downhill villages). Maximisation of a combination of functions leads to optimisation of each individual function.

D. Values of biodiversity: more than money (ES Principles 1 and 4). The functions of biodiversity described under principle C represent various values:

- Economic values: (i) direct monetary income, for example, from the selling of products (timber, fish); (ii) input to other economic activities by providing raw materials; (iii) indirect by providing valuable services that would require large investments if not present (water purification, coastal protection, buffering of precipitation, and so on);
- Social values: such as employment (forestry, tourism, nature management, and so on), safety (protection against tempests), health (air and water quality), quality of life, social security (source of food and income), maintenance of animal and plant life (the idea that species become extinct because of human activities leads to unrest among large sections in society);
- Ecological values: differentiated into (i) future values, or, in other words, how do we keep our world a liveable place for our children and how do we leave them the possibilities to utilise the so far unrecognised potential of biodiversity; (ii) spatial values, relevant for the maintenance of other ecosystems. Examples of the latter are the role of coastal mudflats in the reproduction of marine sea fish populations, or the buffering of rainwater runoff by upstream wetlands, thus protecting downstream areas from flood damage.

E. Stakeholders: guaranteeing attention to biodiversity (ES Principle 12). Goods and services provided by biodiversity represent a value for enterprises, organisations, groups in society or individuals. These parties consequently have an interest (a stake) in the maintenance and/or use of biodiversity. These stakeholders can be divided into direct stakeholders, those that directly benefit from biodiversity, and representtatives speaking on behalf of the direct stakeholders (farmers' co-operatives, professional associations, business councils), or on behalf of biodiversity itself (nature conservation groups).

It can be argued that, if biodiversity does not have any stakeholders in a certain area, biodiversity related issues will not be identified and put on the agenda of decision makers. Identification of stakeholders is consequently of the utmost importance in order to have a complete overview of biodiversity-related impacts of business activities. A complete overview of impacts in this sense thus includes an inventory of impacts on biodiversity (conservation objective), an inventory of uses of biodiversity (sustainable use objective), and an inventory of impacts on the distribution of benefits derived from biodiversity (fair and equitable sharing objective).

The assessment framework does not provide a means to value forms of ecosystem, species or genetic diversity. Valuation of biodiversity can only be done in negotiation with stakeholders. In practice, however, forms of valuation have been formalised in procedures and legislation. Protected species, protected areas, delineation of representative areas for certain ecosystems, identification of biodiversity hot spots, are all examples of ways in which society tries to grasp the complexity of biodiversity and its values for society.

F. Ecosystem approach: participative delimitation of study area (ES Principles 3, 7 and 8). The ecosystem approach defined by the biodiversity convention is taken as a point of departure in the assessment framework. This implies that delimitation of an area subject to analysis has to be done in consultation with stakeholders (or their representatives). Stakeholders are identified on the basis of observed or expected effects of the activity and the subsequent changes in (potential) values of biodiversity for various groups in society.

G. Restraint: only study relevant issues (ES Principle 5). Human activities interfere with an extremely complex and dynamic system. It is often impossible to measure precisely or to predict the biodiversity consequences of human activities, especially in rich tropical ecosystems such as coral reefs and rainforests where the biodiversity is still largely unknown. For this reason, the biodiversity assessment framework emphasises the identification of situations that possibly result in serious consequences for biodiversity and the subsequent identification of aspects of biodiversity that need to be studied. This is to prevent large amounts of data being gathered, for instance, species lists, without necessarily containing relevant information.

Biophysical changes influence certain aspects of biodiversity that are vital to its maintenance:

- Composition, or what is present. This is the most well known aspect of biodiversity. In practice, impact analysis often does not go beyond the description of effects on species composition of higher plant and animal species. Extractive activities directly influence species composition, since they are usually aimed at one or a limited number of species (collection of orchids, fishing for tuna, cutting of meranti trees).

- Structure, or how biodiversity is organised. A limited number of aspects are of disproportional influence on the maintenance of biodiversity (Prins, 2004):[3]
  - spatial structure and scale of the ecosystem in relation to the scale of the biophysical effect (grain size and extent). For example, local erosion has relatively little impact on a river basin since the eroded material will be deposited somewhere else in the basin; contrary to this, a change in river hydrology by construction of a dam will be noticeable in the entire basin and beyond.
  - food-web structure and interactions: the introduction of the predatory non-endemic Nile perch in Lake Victoria has upset the entire ecosystem; dozens of fish species feeding on algae have been eradicated, leading to a turbid and locally deoxygenised lake.
  - presence of keystone species — those for which limited changes in numbers of individuals will have a disproportional influence on their environment (for instance, elephants).
- Key processes, or those processes that are of overwhelming importance for the creation and/or maintenance of ecosystems. For example, a change in the sediment balance on a mangrove coast or a tidal mud flat will immediately alarm ecologists; similarly, changes in the inundation regime of wetlands, the grazing pattern in savannahs, or predation of coral reefs by starfish will ring an alarm bell with ecologists.

If the biophysical changes resulting from an activity and the biodiversity aspects that are influenced by these biophysical changes are known, it is possible to limit an analysis to those issues where the most significant impacts can be expected. It is, furthermore, desirable to define threshold values to distinguish between non-significant and significant changes (that is, the concept of thresholds of potential concern). This can only be practically realised in a specific application of the assessment framework, since such thresholds are highly dependent on the type of ecosystem under influence. Local experts are needed for the definition of such thresholds.

H. Information: external experts and local stakeholders (ES Principles 11 and 12). In practice, the available information from experts or scientific sources may have serious gaps. Local and indigenous people can play a role in filling these knowledge gaps. Often these groups make direct use of the biodiversity resources under analysis and possess relevant knowledge. The role of local groups in identifying and weighing functions and values of biodiversity is often neglected. As a result, functions may be overlooked. Use of local knowledge and exchange of views with local stakeholders are valuable elements of any analysis in order to come to a complete overview of issues.

I. Operational principles Analysis of a number of existing instruments that take biodiversity into account (such as eco-labels, sustainability reporting, codes of conduct) reveals two operational principles that are important for effective implementation of the instrument. These are not directly related to biodiversity but nevertheless merit attention:

- Capacity development: when implementing any kind of biodiversity impact analysis, it is strongly recommended that awareness raising and capacity development activities are carried out back-to-back with the activity. We cannot expect organisations to implement the biodiversity assessment framework at once. Good capacity development is a two-way process in which a ‘learning-by-doing’ approach provides relevant input in the practical translation of the principles and analytical steps. Each situation will in the end require its own adapted situation-specific instruments.
- Procedural and organisational embedding: to make effective use of the assessment framework or any instrument derived from it, the instrument should be embedded in, or adjusted to, an existing institutional setting. Roles and responsibilities must be clear, and preferably some sort of quality control system should be put in place to be able to evaluate and adjust procedures, norms and standards.

Assessment of biodiversity impacts in 11 steps

A biodiversity assessment according to the steps described below is intended to identify any positive or negative impact on biodiversity resulting from human interventions, and to describe the affected biodiversity values for human society. Apart from the identification of potential impacts, the framework also provides insight into the mechanisms through which these impacts occur, and assists in defining

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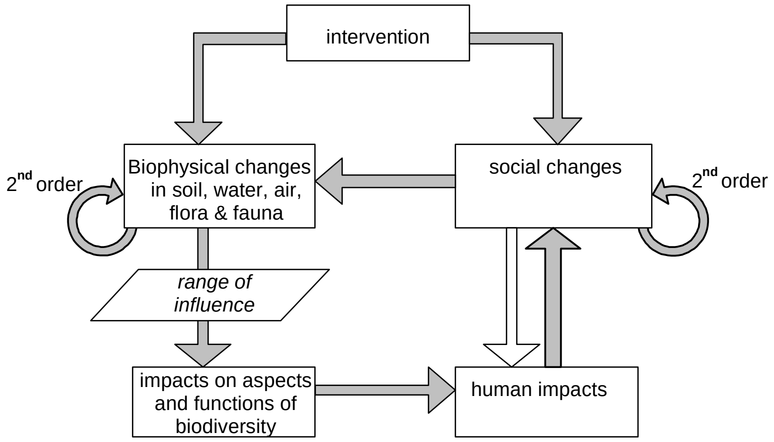

Figure 1. Conceptual framework

Note: Physical and social (and economic) interventions lead to biophysical and social changes, each of these potentially leading to higher order changes. Some social changes may lead to biophysical changes. Within their range of influence and depending on the ecosystem(s) influenced, biophysical changes may influence different aspects of biodiversity. If impacts on the aspects of biodiversity are significant this has an influence on the functions that biodiversity performs (or the goods and services that biodiversity provides). Impacts on the functions of biodiversity will lead to a change in the valuation of these functions by various stakeholders in society. People can react to these changes in the value of biodiversity functions thus creating new social changes.

the minimum information required to determine the extent and relevance of impacts.

Some steps in the framework can only be carried out with the active participation of involved stakeholders, that is, (groups of) people that have an interest in potentially affected biodiversity. Depending on the scope and objectives of an analysis, a group of knowledgeable people can use the framework for a quick scan taking only half a day, or it can be used for a fully fledged impact assessment study of a large project, taking several months. Figure 1 describes the conceptual relations and Figure 2 provides an overview of the sequence of analytical steps.

Step 1: Description of activities

Describe activities: pay attention to the nature of physical interventions, their magnitude, location, duration and frequency. Also pay attention to social or economic activities that may, through social effects, lead to physical effects. Some issues require special attention:

- Identify relevant sub-activities: it should be realised that the implementation of one activity often requires several other activities to be carried out. For example, the dredging of a new port usually

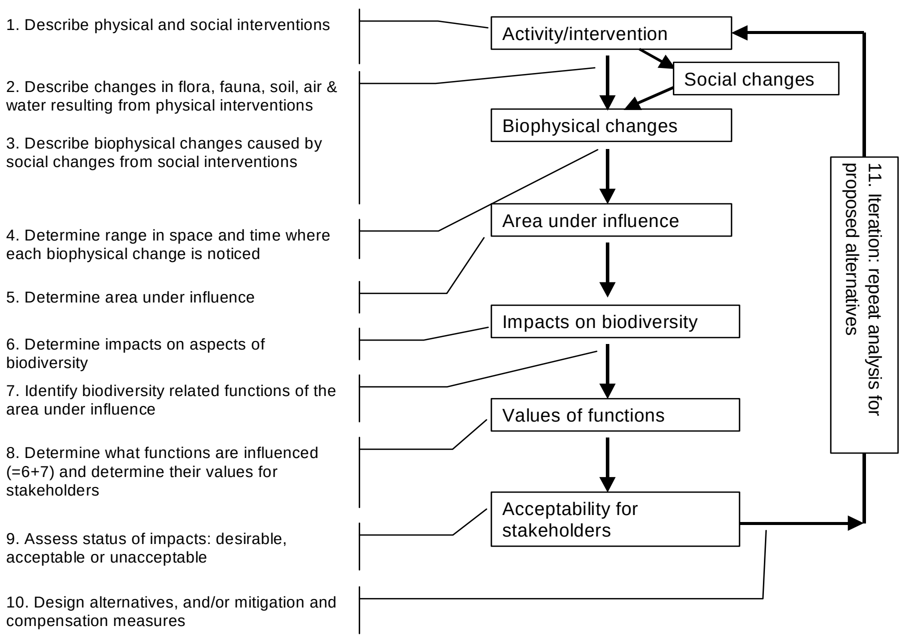

Figure 2. Flow chart of steps in an (iterative) analysis

also implies (i) the dumping of large amounts of sludge somewhere else; (ii) the excavation or deepening of approach channels; (iii) the construction or improvement of feeder roads or railway lines.

- Chain of activities: an activity can often be part of a chain, for example leading from raw material through various processing steps to a final product, which is marketed and after its life span ends results in solid waste. For a biodiversity assessment, it may be necessary to describe and analyse the entire chain; a project proponent than needs to decide on the extent of its own influence and responsibility.
- History of interventions: some activities may have been preceded in the (recent) past by relatively destructive activities. For example, most agricultural or construction work is done on previously converted, drained or reclaimed land. The land conversion is of much more influence on biodiversity than the intended activity. Yet, the intended activity cannot be carried out without land conversion so conversion needs to be included in an analysis. An indicator for biodiversity impact can be the time since the conversion has taken place (more useful to certification, less so to impact assessment).
- Cumulative activities and scale issues. A single groundwater well will hardly influence groundwater levels; one farmer cutting a plot in the Amazonian rainforest will not threaten the rainforest. However, several hundreds or thousands of such activities do matter. The scale of analysis in such circumstances needs to be set at a higher level. Instead of analysing a single activity, the analysis should be made at a more strategic or policy level, for example, for an entire sector in a geographically defined region.[4]

How and by whom: each individual activity that can be distinguished needs to be described in detail, based on project design or available documentation on the company process. Proponents usually have this information available.

Available instruments: generic screening criteria for EIA provided by the CBD (2002), elaborated in some detail for several sectors (for example EBI (2003), for the oil and gas industry) and countries.

Example: a paper-processing company uses a small river for the intake of processing water. On average 5 m^3/s is taken in. Intake is continuous but may vary from 2 m^3/s to 8 m^3/s. The examples in the following steps build on this one.

Step 2: Description of biophysical changes

Biophysical changes: describe the expected or observed direct effects on soil, water, air, flora and fauna resulting from the physical interventions. Determine whether second- and higher-order changes are likely to occur.

How and by whom: experts such as hydrologists, soil scientists, foresters, agronomists and ecologists can predict changes based on scientific knowledge and field observations.

Available instruments: effects on soil, water and air quality are often regulated by legal norms and quality standards. These standards have limited relevance for biodiversity since these are usually designed for human health and safety. Biological effects such as the removal of plants or animals are regulated in some cases (fisheries, forestry).

Example: intake of process water by the paper mill changes the hydrology of the river; on average, water volume drops by 10%, but in dry spells this can increase to 50%. Water levels in the river drop significantly (first-order change); second-order changes are a drying of riverside floodplains, and reduced supply of freshwater at the river mouth thus allowing seawater to penetrate further into the lower river branches.

Step 3: Description of indirect biophysical changes

Indirect biophysical changes: describe expected biophysical changes that result from social (or economic) changes. Social changes result from economic or social project activities.

How and by whom: specialists such as social geographers/sociologists in collaboration with natural sciences specialists; additional inquiries with affected stakeholders are recommended.

Available instruments: not a well developed field of expertise; knowledge and experience predominantly available for transport sector (opening up of untouched areas by road construction leads to influx of migrants, thus putting additional pressure on natural resources).

Example: the construction of a new paper mill creates new employment in an area with low population density. This attracts migrant labourers from other areas who settle in the vicinity of the new activity (social changes) and consequently create additional pressure on the environment by occupying land for housing, gardening, agriculture, and so on.

Step 4: Determination of the range of influence

Range of influence of biophysical changes: for each individual biophysical change the geographical range (area of influence: where and how far away) and time range (when and for how long, permanent or temporary) needs to be determined.

How and by whom: Experts can model biophysical changes or use empirical evidence to predict when and where a biophysical changes will be noticeable. Local stakeholders with their day-to-day experience in the area can input to the appraisal of certain effects. Official norms sometimes provide a legal basis, such as water quality standards. In many cases, norms are lacking or may not be appropriate from a biodiversity perspective.

Available instruments: a large range of scientific and technical means are available to model and predict the scale in time and space on which biophysical changes can be noticed.

Example: the range of influence of a lower water volume in the river, caused by the intake of the paper mill, starts from the intake point, going as far downstream as the change is noticeable; for instance, down to the confluence of the river with a much larger river, where the change in water volume becomes insignificant. In the example in Step 2, the range of influence includes riverside floodplains and the river mouth.

Step 5: Description of the area influenced

Describe the area influenced: when the range of influence (Step 4) is known (and drawn on a map) the types of natural area and/or forms of land-use (that is, the ecosystems) that are influenced can be described. (Man-made ecosystems, often referred to as land-use types, can also represent significant biodiversity functions and values.)

How and by whom: Each biophysical change can have a different area and timing of influence, and will affect an ecosystem in a different manner. The description consequently needs to be done independently for each biophysical change. The work can be carried out by ecologists and geographers.

Available instruments: maps, aerial surveys, satellite images, geographical information systems, field observations, local knowledge.

Example: three different ecosystems are influenced — the river, the floodplains, and the river mouth (estuary). It can also be envisaged that the level of groundwater along the river drops, influencing riverside agricultural and forested lands.

Step 6: Impacts on biodiversity

Impacts on biodiversity: for the ecosystems influenced, analyse how each biophysical change can affect biodiversity by determining whether the biophysical change has an influence on one of the following aspects of biodiversity: composition, structure, or key processes.

How and by whom: determine for each impact its (i) significance;[5] (ii) permanent or temporary nature; (iii) moment of emergence and duration; (iv) reversibility; (v) potential for mitigation. This needs to be done by specialised ecologists.

Available instrument: the CBD guidelines for biodiversity in EIA (CBD, 2002) provide directions. For ecologists, it will not be difficult to determine the potential impacts; the main bottleneck in knowledge is to define the significance of the impact. The concept of 'threshold of potential concern' provides a good starting point; it has been applied in a limited number of practical situations (for example, by van Wilgen *et al* (1998) for fire management in Kruger National Park).

Example: the flooding regime in the floodplains is a key process for the maintenance of wetland biodiversity. A significant change of this regime is an unmistakable signal that biodiversity impacts can be expected.

Step 7: Functions of biodiversity

Functions of biodiversity (or ecosystem services): identify the functions performed by the affected ecosystem; these can be currently exploited functions but also potential future functions. Identification of functions is needed to be able to identify relevant stakeholders. Inherently, stakeholders are (i) local direct users of functions, such as farmers, fishermen, foresters; (ii) local beneficiaries of functions, such as villagers who live protected against forces by nature (for example, dunes or mangroves protect the hinterland against storm surges); (iii) distant beneficiaries (food supply and recreational services for urban inhabitants), and indirect stakeholders, such as (international) NGOs (non-governmental organisations) for nature conservation, scientific institutions and government authorities.

How and by whom: consultation with experts and stakeholders.

Available instruments: a multitude of publications on functions of ecosystems provides guidance; for wetlands and forested ecosystems, multifunctionality has been elaborated in detail in a number of cases, including the economic value of functions. The ongoing Millennium Ecosystem Assessment[6] provides state-of-the-art information.

Example: seasonal flooding of wetlands provides sediments and nutrients for soil fertility, recharges the groundwater reservoirs, is essential for vegetation development, provides possibilities for fish reproduction, and facilitates the feeding of large quantities of migratory birds that use wetlands as a stop-over on their flyway. It also maintains the recreational and tourism potential of the area and is an appreciated traditional feature of the river landscape.

Step 8: Impacts on values of functions

Impacts on values of functions: by combining the results of steps 6 and 7, it is possible to identify the functions that will be affected by the activity and what values these represent for stakeholders (in a positive or negative sense).

How and by whom: with the combined information from Steps 6 and 7, it is relatively easy to find out, in a qualitative manner, which functions will be influenced by the activity. Quantification, however, requires the input of experts. Values of these functions are defined in consultation with stakeholders. Values can differ for different stakeholders, and can be expressed in economic, social or ecological terms; with different valuation by different stakeholders, conflicts of interests may arise. In a negotiation process, each of the impacts has to be assigned a certain weight. The weighting of impacts can be supported by information from a reference situation (which can be (i) the situation without the activity; (ii) a historical situation in cases where the present situation has already been heavily influenced; or (iii) an external reference situation with similar conditions). Be mindful that a situation without an activity may also be subject to changes (autonomous development).

Available instruments: depend on the functions that are considered of relevance. For most functions, expertise is readily available: for instance, fisheries, forestry, hydrology and water quality, ecology.

Example: Direct stakeholders are those that benefit from the activity for which water is being taken from the river — the paper mill; people making a living at the paper mill; and possibly customers of the products. Stakeholders linked to the floodplains influenced include: farmers depending on groundwater for irrigation (economic value); the public water supply company from a nearby city (social value); the association of fishermen (economic value) because the fisheries potential of wetlands and the river will diminish if flooding reduces; recreational fishermen; nature protection groups (ecological value because of the migratory birds); local recreational companies (boat rental, restaurants, hotels) because they fear loss of income from tourists or day trippers; and so on. This example shows that an ecosystem approach aimed at the identification of functions of biodiversity in a well defined area provides a simple means to identify all relevant stakeholders.

Step 9: Acceptability of impacts

Acceptability of impacts: in consultation with stakeholders the status of impacts has to be defined; which impacts are desirable, which can be accepted, and which are unacceptable. The status can differ for different stakeholders, so potential conflicts of interests can be identified.

How and by whom: attention — this step intends to provide relevant information for decision makers, either in public administration or in corporate management; it is *not* a substitute for decision making. Stakeholders have an important role in providing information, they may to a large extent even influence decision making, but they are not the ones making the formal decisions on the way in which an activity is carried out.

Step 10: Alternatives, mitigation and implementation

Alternatives and mitigation: design alternative project activities to avoid or reduce the unacceptable impacts, or to enhance the positive impacts. If an alternative project design is impossible, try to design additional mitigation measures that counteract or compensate negative impacts.

Although alternatives and mitigation is Step 10, in practice, since the framework is intended to be used continuously in an iterative manner, identification of alternatives and mitigation is not left until the end of the process. Even at the earliest stages of project identification one should go through all steps of the analysis, first in a ‘quick and dirty’ way and qualitatively, but continuously refining the information during the process. Overall, consideration of biodiversity issues when identifying alternatives and mitigation is an issue that merits much more attention, but this is outside the scope of this paper. The paper by Gunter and Winfrey (page 17–27) in this special issue looks at the role biodiversity issues played in selection and design of alternatives and mitigation for a US road reconstruction project.

The framework is intended to be used iteratively, so identification of alternatives and mitigation is not left until the end: even at the earliest stages of project identification all steps should be covered, gradually refining the information

Step 11: Iteration

Iteration: repeat the sequence of analytical steps with the identified alternatives or mitigation measures and adjust the information accordingly.

Concluding remarks

The Biodiversity Assessment Framework presented in this paper is an intermediary tool, aimed at translating the unstructured principles of CBD’s ecosystem approach into a coherent framework of thinking. The framework is generic and will be too theoretical for many; it needs further translation into practical instruments. Moreover, it is intended to be a qualitative benchmark for existing instruments and to provide assistance in the development of new instruments. The framework has already been used experimentally to benchmark a number of existing certification and reporting instruments. The appraisal revealed that the instruments were following CBD objectives in varying degree, inconsistencies in interpretation and operationalisation of biodiversity were plainly visible.

Each of the principles and steps in the framework merits further in-depth elaboration and explanation, preferably with examples from practice. At the moment of writing, several projects are being implemented to take this initiative forward. The framework will be modified further for different sectors of industry. Readers are invited to experiment with it and report on their findings.

Notes

1. <http://www.biodiv.org/convention/articles.asp>, last accessed 7 February 2005.
2. The Millennium Ecosystem Assessment (2003) recently described these functions as "ecosystem services", distinguishing among provisioning services (harvestable goods), regulating services, cultural services, and supporting services (necessary for the production of all other ecosystem services).
3. The description of structure as, for example, appearing in IAIA (2001) has been altered, since ecological science has over the last decade provided important new insights. It goes beyond the scope of this paper to go into details.
4. At the time of writing, IAIA's Biodiversity and Ecology section was, in close collaboration with the CBD, collecting case material to further develop guidelines on biodiversity in strategic environmental assessment.
5. For example, in the European Birds and Habitats Directives (European Commission 1992; 1997) significance is expressed in practical terms as the risk of disappearance of a population of a species.
6. <www.millenniumassessment.org>, last accessed 7 February 2005.

References

CBD, Convention on Biological Diversity (1999), "Ecosystem approach", CBD Conference of Parties 5 Decision 6, Nairobi.

CBD, Convention on Biological Diversity (2002), "Further development of guidelines for incorporating biodiversity-related issues into environmental-impact-assessment legislation or processes and in strategic impact assessment", CBD Conference of Parties 6 Decision VI/7-A, The Hague, April.

CBD, Convention on Biological Diversity (2004), "Decision V/6 Ecosystem Approach. Decision VII/11 Ecosystem Approach", available at <http://www.biodiv.org/decisions/default.aspx?m=COP-07&id=7748&lg=0>, last accessed 7 February 2005.

EBI, Energy and Biodiversity Initiative (2003), *Integrating Biodiversity Conservation into Oil & Gas Development* (The Energy and Biodiversity Initiative, Washington DC).

European Commission (1992), "Council Directive 79/409/EEC on the protection of wild birds (Birds Directive)", available at <http://europa.eu.int/comm/environment/nature>, last accessed 7 February 2005.

European Commission (1997), "Council Directive 92/43/EEC on the conservation of natural habitat and of wild fauna and flora (Habitat Directive)", amended by Council Directive 97/62/EC, available at <http://europa.eu.int/comm/environment/nature>, last accessed 7 February 2005.

IAIA, International Association for Impact Assessment (2001), *A Proposed Conceptual and Procedural Framework for the Integration of Biological Diversity Considerations within National Systems for Impact Assessment*, Report of the Netherlands Commission for EIA.

Millennium Ecosystem Assessment (2003), *Ecosystems and Human Well-being: A Framework for Assessment* (Island Press, Washington DC).

Prins, H H T (2004), Wageningen University, The Netherlands, personal communication.

Slootweg, R, F Vanclay and M L F van Schooten (2001), "Function evaluation as a framework for integrating social and environmental impacts", *Impact Assessment and Project Appraisal*, 19, pages 19–29.

Slootweg, R, and A Kolhoff (2003), "A generic approach to integrate biodiversity considerations in screening and scoping for EIA", *Environmental Impact Assessment Review*, 23, pages 657–681.

van Wilgen, B W, H C Biggs and A L F Pogieter (1998), "Fire management and research in the Kruger National Park, with suggestions on the detection of thresholds of potential concern", *Koedoe*, 41, pages 69–87.