Ecosystem service indicators in Flanders: Are we measuring what we want to manage?

Wouter Van Reeth

INBO.R.2014.2763989

D/2014/3241/225

Key Findings

I - on the need for ecosystem service measures and indicators

1. Public, political and institutional awareness of the status of ecosystem services and their relevance for human well-being is growing, but is still relatively poor.
2. Ecosystem service indicators can help to increase the visibility and raise awareness of our stock of natural capital and its performance in delivering flows of services and benefits.
3. Indicators can facilitate communication between scientists, policy makers and local stakeholders. They should however be part of a broader knowledge base that includes scientific expertise, policy expertise and knowledge of local stakeholders.

II - on assessments of existing indicators

4. Existing sets of indicators that are currently used to inform biodiversity policy focus more on taxonomic diversity and less on ecosystems' functional capacities and values.
5. Existing ecosystem service indicators focus mostly on services that are already the focus of market- or regulation based policy programmes. Generally speaking indicators are mostly developed for provisioning services, and less so for regulating, cultural or supporting services.
6. Existing indicators are overall rated rather low in their ability to convey information to policy makers, and in the comprehensiveness with which they cover complex ecosystem services.
7. The use of existing indicators is also hindered by limits in data availability.
8. Sets of measures and indicators may affect policy and decision making both in a desirable and in an undesirable way. They need to be assessed on their validity, as well as on their legitimacy and functionality.

III - on the development and use of indicators in Flanders and Belgium

9. Ecosystem performance can be used as a construct to capture ecosystems' capital basis (ability to deliver goods and services), the actual flow of goods and services delivered and the net benefits that result from them.
10. Measures and indicators need to use biophysical, monetary and other non-monetary units to capture ecosystem performance in a comprehensive and balanced way.
11. Sets of indicators should inform policy makers and other stakeholders about drivers, pressures, states, impacts and responses. Given the current goals in biodiversity policy, state indicators should address ecosystems from an intrinsic value perspective as well as from an anthropocentric perspective like ecosystem performance.
12. To link ecosystem performance indicators to policy cycles, they need to be integrated with planning processes, decision support tools, monitoring schemes and evaluation research.
13. Developing indicators on ecosystem performance should be organized and co-ordinated across policy domains, across scientific disciplines and across science/policy/stakeholder-boundaries.
14. The conceptual framework presented in this document could serve as a basis to set up an online knowledge system for indicators on biodiversity and ecosystem performance, to support and connect communities of science and practice.

Contents

Foreword

The work on this report started under the research project 'Belgium Ecosystem Services' (BEES), funded by the Belgian federal ministry of science policy (BELSPO) in 2011-2012. Most of the empirical analysis for this report was done in 2011. The findings were presented in various posters or presentations at INBO and on international workshops and conferences, among others the 4th ESP-conference in Wageningen, Netherlands (October 2011) and the TEEB-conference in Leipzig, Germany (March 2012). In 2013 the text was synthesized and updated for a book chapter in Jacobs S., Dendoncker N. and Keune H. (eds.), Ecosystem Services: Global Issues, Local Practices, published by Elsevier in 2014.

Given the potential and importance of ecosystem service indicators for informing policy networks, ecosystem managers and other stakeholders, the text was revised and extended as a background document for the Flemish Nature Report 2014: Status and Trend of Ecosystems and Ecosystem Services in Flanders (available in dutch at www.nara.be).

This report presents an overview of the ecosystem service indicators that were readily available for Flemish environmental and nature policy around mid 2011, at the time when a new global and European Biodiversity Strategy was being launched. In future volumes of the Nature Report, scheduled for 2016 and 2018, the list of available indicators (see Annex 1) will be updated further. The goal is to come up with a diverse yet sufficiently compact set of online indicators, preferably at the spatial scale of Flanders. This set could be made available online and should be updated on a regular basis (e.g. between 1 and 5 years). The scope of the indicators should be diverse enough to cover a relevant range of provisioning, regulating and cultural services and their values. At the same time it should be compact enough to be manageable, both for users of the information as well as for the producers of the underlying data.

The author wishes to thank Melissa Ceuterick, Sander Jacobs, Hans Keune, Anik Schneiders, Francis Turkelboom, Peter Van Gossum and Ann Van Herzele for their comments and suggestions on earlier versions of this report.

1. Introduction

Since the publication of the Millennium Ecosystem Assessment (MA) in 2005 the concept of ecosystem services (see Box 1) has caught widespread attention among scientists and policy makers. Already the first years after the MA the number of scientific publications addressing ecosystem services rose exponentially (Fisher et al., 2009). In 2010-2011 new global and European biodiversity strategies were adopted which explicitly targeted the link between ecosystems, ecosystem services and human well-being. In October 2010 the 10th Conference of the Parties of the Convention on Biodiversity adopted the new 'Strategic Plan for Biodiversity 2011-2020' with the 20 Aichi-targets (C.B.D., 2010). In May 2011 the European Commission issued with 'Our Life Insurance, Our Natural Capital' the new EU Biodiversity Strategy to 2020 (EC, 2011). Although these strategies were built on existing and on-going programs of nature conservation (e.g. Natura 2000) and multi-functional use of the open space (e.g. agriculture, forestry & fisheries) the new strategies illustrate an evolution in the discourse on nature conservation among policy makers, scientist and stakeholders. The new 2020 biodiversity targets explicitly refer to halting the degradation of ecosystem services, in addition to halting biodiversity loss. These strategies increasingly adopt a functional, anthropocentric rationale to

Box 1. Ecosystem services, benefits and well-being

Some of the most cited publications have defined ecosystem services as 'the benefits which people derive from nature' (Costanza, 1997). Via the construct of ecosystem services, ecosystems are also connected to human well-being. As the use of these concepts proliferated among scientists, policy makers and stakeholders, more precise definitions have been proposed. The definition that is used in this chapter follows (Fisher et al., 2009) who consider ecosystem services to be 'the aspects of ecosystems, utilized actively or passively, to produce human well-being'. They include therefore ecological phenomena that are used or consumed, directly or indirectly, by humans.

Building on this definition we can further specify the distinction between ecosystem services, benefits and well-being. Ecosystem goods and services are the output that flows from ecosystems. From the use or consumption of this output people derive benefits, which are not an output but an *outcome*. A distinction between output and outcome is important for the development and interpretation indicators, especially when they are to inform decision makers or to support accountability (Bouckaert, 1995; Hatry, 1999).

These benefits in turn contribute to human well-being (*impact*). Well-being is a more holistic, multi-dimensional concept that represents an aggregation of benefits. To some extent it may be captured in monetary terms (e.g. some minimum threshold for income/capita). Usually other quantitative (e.g. life expectancy) or qualitative categories (e.g. perceptions and statements of happiness) need to be added for a more complete understanding.

motivate the conservation or restoration of ecosystems. Also communication to the press indicates how biodiversity conservation is increasingly advocated from an anthropocentric point of view (e.g. (UNEP, 2010). The policy documents reflect the idea that "ecosystems are capital assets which, when properly managed, can yield a flow of vital services" (Daily, 2000). As a result, maintaining or restoring the *performance of ecosystems* (see section 2.3) in order to do so, has explicitly become part of biodiversity policy and nature conservation.

Parallel and interacting with these developments in policy circles the international study project 'TEEB' (The Economics of Ecosystems and Biodiversity) resulted in a series of reports for different target audiences (www.teebweg.org). The TEEB reports contain concepts, methods and evidence to recognize, demonstrate and capture the value of ecosystems (TEEB, 2010). From the outset TEEB strongly advocated the development of ecosystem indicators, based on the management conundrum 'you cannot manage what you do not measure' (TEEB, 2008). Also earlier international study projects on biodiversity like the Global Biodiversity Assessment (1995) and the MA (2005) had already suggested the development of indicators to increase the visibility and manageability of ecosystems and their services (Heywood & Watson, 1995; MA, 2005b).

In Belgium, most of the policy competences relating to ecosystem services (e.g. biodiversity, environment, agriculture, spatial planning, housing, mobility, infrastructure, …) have been transferred in the 1980's and 1990's to the institutional level of the regions (Flanders, Walloon Region and Brussels Capital Region). However the North Sea, (coastline and fisheries not included) is still the competence of the Belgian federal government as are parts of food and health policy. In this chapter we focus on what has happened in the Flemish Region.

> "Not everything that can be counted counts, and not everything that counts can be counted."
>
> (William Bruce Cameron, 1963)

Since the adoption of the new biodiversity strategy at the global and EU-level no major new policy initiatives have been taken yet in Flanders.[1] The Flemish Government was elected for the period of 2009 – 2014, in July 2014 a new coalition was installed for a 5-year period. The Flemish Environmental Policy plan (2011-2015) which follows this 5-annual cycle was by and large put together before the adoption of the new global and European biodiversity strategies. As a result, the shift in discourse towards natural capital, ecosystem services and human well-being has not yet worked its way into the new headline policy targets or indicators. Nevertheless, the plan already states that the value of ecosystem services should be reflected in policy, also for ecosystems abroad (Departement LNE, 2011). At the same time, several existing policy programmes already focus on maintaining or restoring ecosystem services, for instance via subsidies to NGO to increase accessibility of nature reserves; guidance and subsidies to private forest owners for more sustainable management; agri-

[1] In 2014 the Flemish legislation with regard to nature conservation ('Natuurdecreet') and forest ('Bosdecreet') was integrated. The implementation of this new legislation, e.g. the drafting of new executive decisions by the Flemish Government was still ongoing at the time of drafting this report. An analysis of this revised legislation has not yet been included in this report.

environment schemes for farmers to prevent erosion or improve water quality, etcetera. Except for these policy measures, indicators which assess flows (quantity, distribution, values) of ecosystem services have not been included yet in the Flemish biodiversity indicator reports (cf. section 3).

This report presents and discusses the state of the art in Flanders with regard to ecosystem service indicators in 2011. In order to inventory and analyse the existing indicators we adopted a systems approach, based on findings and recommendation for the scientific literature (see chapter 2). Next we apply this framework to assess to what extent the existing and proposed indicators cover our stocks of natural capital, flows of ecosystem services, benefits and well-being (see chapter 3). Chapter 0 continues with some findings from public administration theory on the measurement and the use of indicators for management and policy making in a political context. This allows to assess to what extent we are currently able to measure what we (may want to) manage. Chapter 5 presents the conclusions as well as approach for the development and use of ecosystem service indicators under the new Biodiversity Strategy.

2. A systems approach for the development and interpretation of indicators

2.1. Why indicators?

The use of indicators (see Box 2) to support public policy and management became increasingly popular throughout the 1980's and 1990's. Several OECD-countries witnessed public sector reforms that focussed on saving public expenditures and reducing the public debt, on improving the performance of policy programs and public organizations and on increasing government's accountability towards the general public (O.E.C.D., 1993; O.E.C.D., 1995). Performance measurement and management became key elements of the 'new public management' doctrine although many of the concepts and

Box 2. What are 'indicators'?

The (dutch) van Dale dictionary (edition 1999) defines an indicator as (1) (mathematics) a number that represents a reliable indication for the value of something; (2) (chemistry) a substance that, when added during a reaction, indicates how this reaction proceeds or (3) (generally) a phenomenon that suggests something or a variable that indicates something.

In the public administration and policy science literature, indicators have been defined in various ways (Halachmi & Bouckaert, 1996; Hatry, 1999). These definitions are usually based on

1. their content, i.e. *what* they measure & communicate. Examples include input, output and outcome indicators.
2. their format, i.e. how that content is expressed and *presented.* Examples include definitions based on graphic presentation, response time or scale.
3. their functionality, i.e. how they can be *used*. Examples include indicators for economic policy, budget or management control, monitoring progress towards policy targets, increasing accountability or raising awareness.

Along with these definitions there is often a normative undertone, referring why and how they should or shouldn't be developed, presented and used.

In this chapter we define indicators to be selective representations of a phenomenon that are presented in a graphical format. It is the selectivity from which indicators get their focus and policy relevance. But this selectivity at the same time introduces values, political choices, value judgements and therefore a certain bias. Explicit acknowledgement of this selectivity can help avoid misinterpretations or political abuse of the conveyed information.

Indicators can be expressed in a quantitative and qualitative scales, based on a data collection that can be repeated (in principle) across time and space. Typical graphical representations are line, bar or pie graphs and maps. A reference to a policy target (e.g. distance to target), historical observations (e.g. time series) or observations on other locations (e.g. experiments, benchmarks) can be included in the presentation to assist or suggest interpretation.

practices had their roots in reforms of the 1950's and 1960's (Hatry, 1999).

A key element in these performance oriented reforms has been the idea to increase the visibility of the goals and strategies, budgets, processes, and results of policy programs. The assumption was that by increasing the transparency of government, the rationality of decision making could be enhanced and that this would improve the effectiveness and efficiency of policy programs and, ultimately, the legitimacy of government itself. The reform discourse has since then evolved from 'public management' to 'governance'. However the basic approach of setting result-oriented policy goals and targets, monitoring progress via indicators and using those in policy plans, management contracts and evaluation reports is still a key element of most policy programmes and policy domains, including biodiversity policy (e.g. (EEA, 2009)).

Both the MA and TEEB have strongly advocated the development of ecosystem service indicators. The MA suggested the selection and development of appropriate indicators of ecosystem conditions, ecosystem services, human well-being and drivers of ecosystem change (MA, 2003). These indicators were to be highly relevant to policy makers, easily understood and effectively convey the key findings about the impact of ecosystem change on human well-being. The MA concluded that there were at the time "no widely accepted indicators to measure trends in ecosystem services, much less indicators that measure the effect of changes on human well-being" (Layke, 2009). In 2008 the MA Follow-up Advisory Group recommended to the COP-9 meeting of the Convention on Biological Diversity (CBD) in Bonn the use of economic valuation tools and ecosystem service indicators as key approaches for the mainstreaming of ecosystem service considerations across policy sectors and levels of government.

Mace and Baillie reviewed the sets of headline indicators used under the CBD and by the European Commission to monitor progress to the 2010 target (Mace & Baillie, 2007). They concluded that the available data tend to emphasize taxonomic diversity rather than ecosystem functions and services. Feld et al. examined 531 indicators reported in 617 peer-reviewed journal articles between 1997 and 2007. Despite the launch of policies at multiple scales and government levels, policy still lacked a "comprehensive indicator system suited to detect and measure the state and trends in biodiversity and their implication on ecosystem service provision" (Feld et al., 2009).

The TEEB-report for national and international policy makers stated as key message that "ecosystems and biodiversity are our stock of 'Natural Capital' – they lead to a flow of benefits that support societal and individual well-being and economic prosperity. We do not measure this capital effectively enough to ensure its proper management and stewardship. (…) Without suitable indicators or accounting, we lack a solid evidence base for informed policy decisions." (ten Brink et al., 2011)

TEEB concludes that the public, political and institutional awareness of the status of ecosystem services and the threats they face, is relatively poor. To increase this awareness it recommends the development of a compact set of headline biodiversity and ecosystem service indicators. These indicators should fit into a coherent framework for analysis "that addresses functional relationships between nature and human well-being".

They should also be linked to SMART[2] policy targets, to serve as a management dashboard and monitor policy progress. The streamlined set of headline indicators should be supported by more detailed and elaborate sets of indicators for measurement and monitoring, or for evaluating specific policy instruments. Ecosystem service indicators should also be used to complement traditional macro-economic indicators.

All these definitions, evaluations and recommendations with regard to indicators illustrate how neither the development nor the use of indicators are neutral, value-free exercises. This means that also the context in which indicators are developed and used affects the criteria by which indicators are to be assessed (see further chapters 3 and 0). The MA also explicitly acknowledges this, for instance by stating that "the more involved decision makers and stakeholders are in the selection of indicators, the greater will be their acceptance of results of the assessments" (Millennium Ecosystem Assessment, 2003). At the same time the MA considered indicator-based assessments as only one of the vehicles to convey information to decision makers and other stakeholders, together with accounts, spatial and (quantitative and qualitative) science assessments.

Box 3. MA recommendations on indicators

As to what constitutes a "good indicator" the MA posits that indicators should be (MA, 2003)

- representative: cover the most important aspects of ecosystems and their services and indicate the extent to which the objective of an ecosystem service is met;
- reliable: well founded, accurate, measured according to accepted scientific standards;
- feasible: the data are readily available or can be obtained at a reasonable cost.

In addition, the usefulness of indicators for policy making is believed to depend on the extent to which indicators:

- relate directly to policy options, goals or targets;
- capture change over time;
- identify critical thresholds or the irreversibility of a change (cf. precautionary principle);
- provide early warning;
- characterize the optimal, sufficient or insufficient level of a given ecosystem service.

Indicators are to be used in indicator-based assessments to track and communicate on a regular basis:

- whether actions or policies are implemented;
- whether they achieve their intended results;
- whether new factors have arisen.

---

[2] SMART: specific, measurable, accepted, realistic, time-specific

2.2. Defining 'ecosystem performance'

A central line of argumentation to raise awareness and develop a more ecosystem services oriented policy is the continuing degradation, both in quantity and in quality, of natural ecosystems. This affects their performance, as functional entities, in sustaining economic prosperity for specific stakeholders, and human well-being in general. Therefore we approach ecosystems as a form of renewable (but also depletable) natural capital (Costanza & Daly, 1992; Daily, 2000; de Groot et al., 2010b; MA, 2005b). Capital is a stock that yields an output, which may be a flow of tangible goods (e.g. biomass, freshwater, …) or of biophysical or even relational services (buffering floods, erosion control, identity and social relations depending on landscape features, …) (see Figure 1). If the goods produced by an ecosystem are left untouched they become part of the capital stock and renew or transform it, to support other or future flows of goods and services (see feedback loop in Figure 1). Timber from a forest or fish from the sea are typical examples. If these goods on the other hand are harvested and removed from the ecosystem, they can be directly consumed by humans or used as a resource in a production process. In most cases this consumption will imply use as a resource in a production process, together with input from manufactured, financial, human and social capital. Intensifying the harvest or extraction of ecosystem goods can reduce the capital stock's ability to provide these same goods in the future. It can also diminish the capital stock's ability to perform other services. For instance if more wood is removed from a forest than it can regenerate, both the stock of goods (e.g. timber) and the capacity to supply services (e.g. purify air, filter water, prevent landslides) will decrease. The future performance of the ecosystem is thus undermined or, in other words, the exploitation of the ecosystem may become unsustainable if the quantity or quality of the capital stock decreases below a minimum threshold. A sustainable flow of goods and services that does not undermine ecosystem health and performance (also called the maximum sustainable yield) can be regarded as a form of natural income that increases economic prosperity and human well-being. However in our mainstream economic accounts and information systems, any harvest and consumption of ecosystem goods and services is regarded as income, even when it exceeds sustainability limits.

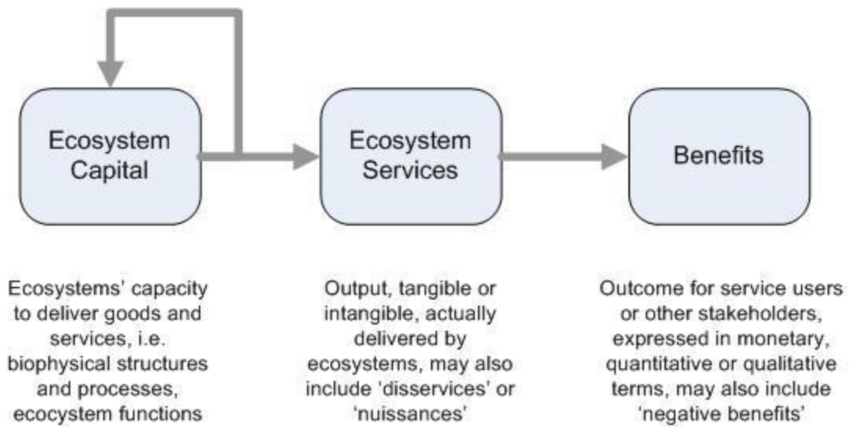


Figure 1. *Components of ecosystem performance*

Performance in public management literature refers to the results (outcomes) and efficiency of services or policy programmes (Hatry, 1999). When ecosystems are viewed as functioning entities with a natural capital base that delivers output (goods & services), generates benefits (outcome), then 'ecosystem performance' needs to capture the capital base, output and outcomes of ecosystems. Ecosystems' capital base refers to their capacity to supply a sustained flow of goods and services. It includes elements of ecological structure, processes & functions, and ecosystem health (quantity, diversity & condition). Also 'intermediate ecosystem services' and the underlying ecological structures and processes, the ecosystem's 'back office' so to speak, can be treated as a (functional) part of the ecosystem capital (Fisher et al., 2009). For instance, the hydromorphological status of a river and the share of natural land cover in a river basin are attributes of the ecosystem health that affect its capacity to retain or slow down the passage of water. Ecosystem output consists of the final services actually delivered by ecosystems to human beneficiaries or the goods harvested for human use. For instance, the volume of water that is retained by the river valley after a long or intense period of rainfall. The benefits then represent the outcomes of the ecosystem services, enjoyed (or suffered) by affected stakeholders. They can to some extent be expressed in monetary terms (e.g. avoided/incurred damage costs), in physical terms (e.g. number of houses saved/lost) or in human terms (e.g. number of lives saved/lost). Ecosystem performance thus refers to a multi-dimensional and multi-faceted construct. Indicators need to cover stocks and flows, ecosystem quantity and quality, supply and demand of services, volumes and values and their temporal and spatial distribution between regions or stakeholders.

Existing indicator assessments or reviews tend to cover the components of ecosystem performance only partially, or fail to make the distinction between them. Some authors assessments have focused on the flow of services (e.g. (Layke, 2009)). Others have distinguished between stocks and flows (e.g. (de Groot et al., 2010a; UNEP-WCMC, 2011) but mix supply and demand. In other cases quantitative volume measures are juxtaposed with monetary benefit measures, thus mixing output indicators with outcome indicators (Layke, 2009; ten Brink et al., 2011).

It is clear that the construct of ecosystem performance cannot be captured in a single index, scale of measurement or metric. An indicator or measure that captures ecosystem health does not reveal the benefits actually enjoyed. An indicator that shows the amount or distribution of benefits does not reveal whether this is sustainable, etcetera (de Groot et al., 2010a; UNEP-WCMC, 2011)

Policy and governance information systems should emulate this diversity and complexity. Sets of indicators will need to refer to the different dimensions of ecosystem performance, will have to be based on different types of measurement and data analysis, via interdisciplinary and transdisciplinary approaches. There is a tension between the requirement of completeness and thorough understanding, and the need to limit sets of indicators sufficiently to prevent information overload for users or exuberant costs of data collection for producers.

At the same time it is unlikely that ecosystem performance can be entirely captured or wholly explained, let alone be managed, by means of indicators alone.

Indicators should therefore be part of a broader knowledge basis that includes scientific research as well as local stakeholder knowledge to help explain and understand the observed indicator trends.

Indicators however can help in pointing out critical thresholds, can provide early warnings for irreversible changes or suggest general trends which can be used to inform debates in policy and society (MA, 2003). They can also help to point out issues which merit more attention, or consultation with policy implementers or local stakeholders.

2.3. A systems approach to ecosystem service indicators

Our understanding of the functional relationships between human activities, natural capital, ecosystem services and human well-being is still very incomplete (Daily, 1997; de Groot et al., 2010a). Also the interdependencies between levels of biodiversity and ecosystem service capacity have not been cleared out thoroughly, although general patterns have been proposed (Braat et al., 2008; Elmqvist et al., 2010). In this complex web of causality, non-linearity and uncertainty the use and interpretation of indicators is tricky. Review reports and articles have suggested to embed policy indicators in a DPSIR[3]-like framework or model (Braat et al., 2008; de Groot et al., 2010a; Layke, 2009; Müller & Burkhard, 2012; ten Brink et al., 2011; van Oudenhoven et al., 2012). Such a framework may serve as a structure to organize data and present policy relevant information. Positioning the indicators along a logical structure can also assist their interpretation. Further it can be used as a framework for action, highlighting areas of interest on which policy measures and programmes should focus.

In order to analyse the ecosystem service indicators that are in use or have been proposed in Flanders we adopted a framework based on those suggested and used by the World Resources Institute, TEEB and UNEP's World Conservation Monitoring Centre to structure and analyse ecosystem service indicators (see Figure 2 and Box 4). WRI's Ecosystem Service Indicators Database (www.esindicators.org) is an example of how this could be set up in practice. A database and web-application can serve as a science-policy-stakeholder interface to present data in an easily accessible and understandable way and to facilitate mutual learning between producers and users of this information.

The relationship between the traditional intrinsic value-based approach to nature conservation approach and a more anthropocentric one based on ecosystem services, is complex. There are cases of synergies, where nature conservation yields net economic benefits; of complementarity where biodiversity conservation yields benefits to adjacent areas of more intense land use; and cases of conflict where the opportunity costs of nature protection outweighed the measured economic benefits. Also on the level of biodiversity (e.g. species diversity) that is required for a sustained provision of ecosystem services, rivalling hypotheses and empirical studies have been proposed (e.g. redundancy, rivet or portfolio hypothesis). A changing societal context, conservation level or scale of exploitation can further alter the nature of

[3] DPSIR: driving forces, pressure, state, impact, response

the relationship. Whatever the relationship between biodiversity and ecosystems' capacity to support human well-being, indicators designed to monitor and communicate the former do not necessarily provide information on the latter, or vice versa. Therefore we separate them analytically in Figure 2, acknowledging the intricate and complex relationship between them.

Using such a framework to select or develop indicators often leads to a debate as the delineation of the concepts is often a matter of choice and interpretation, rather than of hard science. Firstly, the concepts in the framework can be sub-divided or synthesized, depending on the purpose and focus of the indicators. Moreover addition, the same indicator can be positioned in different boxes, depending on one's viewpoint or on the context in which the indicator is used. For instance, an indicator reporting the frequency of visits to nature reserves may be interpreted as a proxy for a cultural ecosystem service or rather as a pressure, if the focus is on the decrease of breeding birds in a given area. A farmer may choose to regard 'pollination' as a supporting service because it supports the provisioning ecosystem service 'nutrition' while a beekeeper may wish to classify it as a provisioning service. As a third example, data about farmers' willingness to participate in agri-environment schemes can be said to relate to 'policy and stakeholder strategies and interventions', but also to agricultural practices which are typically catalogued under 'drivers'. Although these operational definitions are important, they are a matter of convention that grows from practice, rather than of 'objective' science. Moreover, the exact classification choices is likely to depend on the use and decision context (Fisher et al., 2009). The use of a conceptual framework will therefore only lead to a valid, useful and balanced set of indicators to the extent it is supported by a well designed participatory process with all relevant stakeholders.

Table 1 presents some examples of Flemish ecosystem service indicators, structured according to this systems approach. A complete overview of the 152 collected indicators is presented in Annex 1. This set is analysed in chapter 3.

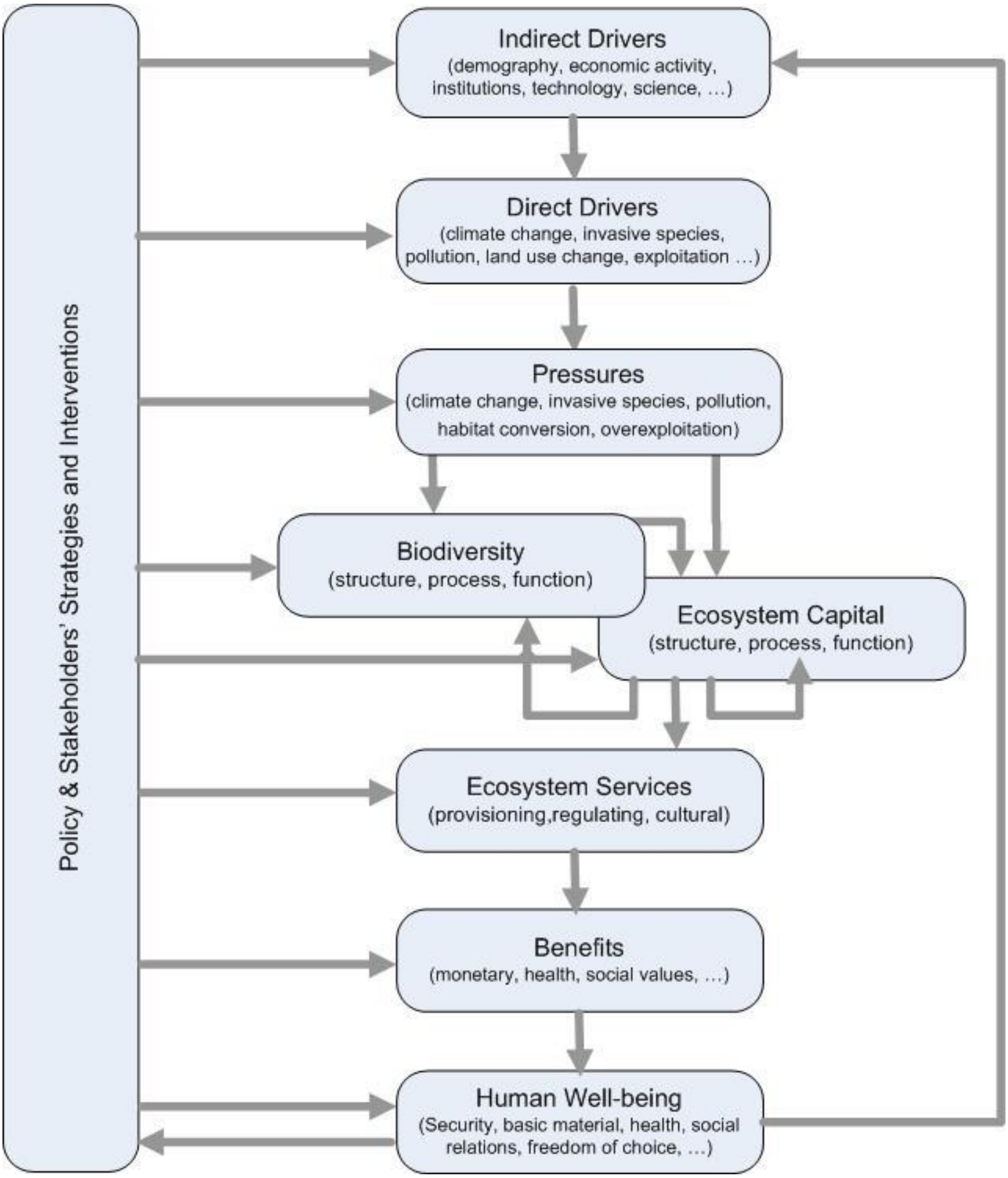


Figure 2. *A systems approach to ecosystem service indicators (Adapted from (de Groot et al., 2010a; de Groot et al., 2010b; Institute, 2009; UNEP-WCMC, 2011))*

Box 4. DPSIR and ecosystem services

Drivers may be natural or social phenomena or human activities that put a pressure on the environment and ecosystems in a direct or indirect way. Indirect drivers refer to socio-economic conditions like demographic trends, poverty, political system, cultural characteristics which affect direct drivers. They may also refer to natural phenomena, for instance natural drivers of climate change. Direct drivers are the human activities that create pressures on the environment and on ecosystems, for instance through the combustion of fossil fuels, the cultivation or exploitation of terrestrial or marine territories, urbanization and transportation, etc..

Pressures are biophysical influences on the environment and on ecosystems like emissions of eutrophic, acid or polluting substances, fragmentation, groundwater extraction or invasive species.

Biodiversity refers to the condition and biological integrity of ecosystems and the status and trends of species from an intrinsic value point of view, regardless of their functional value towards ecosystem services and human well-being. It encompasses genetic, species and ecosystem diversity. Biodiversity conservation however is strongly interwoven with ecosystem health and its capacity to support services (see above). We explicitly separate the intrinsic value perspective here from the anthropocentric perspective (ecosystem capital). Indicators of intrinsic value are not designed to assess, and do not necessarily represent, ecosystems' service providing capacity, or vice versa (see (MA, 2005a; MA, 2005b; Schneiders, 2015; Van Reeth et al., 2015) for a more extensive treatment of the biodiversity – ecosystem service relationship).

Ecosystem capital represents in this framework an anthropocentric perspective on ecosystem structures (e.g. species populations, habitats), processes and functions that generates flows of goods and services which may be appropriated for human use. It focuses on those components of biodiversity which have, directly or indirectly, a known functional value to humans (e.g. service providing units (Luck et al., 2009); ecosystem service providers (Kremen, 2005).

Ecosystem services are the output supplied by the ecosystem. They may be tangible goods that are harvested or extracted from the ecosystem for human use (e.g. food harvests, timber or biomass, freshwater for agricultural or industrial use) or services that support human activities (e.g. pollination by wild pollinators, water purification, erosion control). This output includes what is sometimes called 'disservices' or 'nuisances' (Dunn, 2010; Lyytimäki & Sipilä, 2009; Zhang et al., 2007). For instance farmers may experience a decrease in crop yield because of wild herbivores residing in nearby forests and foraging on their farmland. Green infrastructure in built areas may cause material damage, or may require inspection, maintenance and replacement in order to avoid damage costs.

Box 4 (continued)

The *benefits* constitute the outcome of this use of ecosystem goods or services. They can refer to levels of health, safety or other individual or collective experiences or perceptions affected by (changes in) ecosystem services. They can be expressed in terms of quantity, utility, happiness, euros or any other form of individual or collective appreciation expressed by humans. The term benefits has therefore a broader meaning than the economic value of services, expressed in a monetary unit. Examples of benefits which increase welfare may be increased health from biological nutrition, fresh air & clean water, or safety from natural disasters. Examples of 'negative benefits' which decrease welfare may be income loss or increased health expenditures from diseases spread via natural ecosystems (e.g. increased risk of meningitis from infection by ticks in Eastern and Central European forests).

Human well-being refers to the state of people's physical, economic, social and spiritual well-being, for instance access to clean water, levels of education, percentage of unemployment, criminality records. Well-being is often put on the opposite of a continuum with poverty or 'ill-being'. It is not restricted to just material or economic wealth, although those are certainly part of it. It refers to the extent to which people's basic material needs for a good life are met, and whether they experience security, a good health, good social relations and generally freedom of choice and action (MA, 2003; McMichael et al., 2005).

Policy and stakeholders' strategies and interventions refer to the decisions and behaviour (production, consumption, …) via which governments, companies, NGO, interest groups and other stakeholders (try to) shape the socio-ecological system of which they are part. These strategies and interventions may be explicitly focused on each of the framework's components, for instance on the drivers (e.g. education, economic policy) or pressures (e.g. removing invasive species, preventing environmental pollution) or on a combination of them (e.g. acquisition, restoration and management of protected areas).

Table 1. *Illustration of 16 indicators of ecosystem performance. The names in the reference column refer to the lead author in the chapter of (Jacobs et al., 2010), from which the indicators were compiled. The full list is presented in Annex 1.*

Indicator Classification (4 tiers)	**Data unit**	**Format**	**Reference**
Ecosystem Capital			
Ecosystem processes & functions			
Water cycling			
Infiltration potential of soil in Flanders	*qualitative scale*	*regional map*	*Staes et al., 2010:28*
Water retention potential in Flanders	*qualitative scale*	*regional map*	*Staes et al., 2010:30*

Capital stocks			
Water cycling			
Ground water level	*concept*	*text*	*Staes et al., 2010:89*
Carbon stocks			
Carbon stocks in soil & biomass of forests	*kg C/m²*	*regional map*	*Lettens et al., 2010:66*
Primary production			
Standing wood stock (volume, species, age)	*m³, %*	*graph*	*Van der Aa, 2010:125*
Air quality			
Average annual PM10-concentration	*µg/m³*	*regional map*	*De Meulenaer et al., 2010:223*
Ecosystem Services			
Provisioning services			
Nutrition			
Crop production	*ton/year*	*number*	*Turkelboom, 2010:112*
Materials			
Timber harvest from public forests and forest groups	*m³/year*	*graph*	*Van der Aa, 2010:126*
Regulating services			
Regulation of wastes, pollution & nutrients			
Nutrient (N, P) removal in the Scheldt estuary	*kg N,P/ha*year*	*table*	*Vandevenne, 2010:53*
Climate regulation			
Carbon sequestration by farmland & forests	*ton C/ha*year*	*number*	*Lettens et al., 2010:70-71*
Cultural services			
Recreation services			
Vicinity of green space for built areas	*km*	*regional map*	*Simoens, 2010:145*
Benefits from Ecosystem Services			
Benefits from provisioning services			
Benefits from nutrition			
Benefits from agricultural and horticultural production	*€/year*	*graph*	*Turkelboom, 2010:113*
Benefits from materials			
Benefits from timber harvest	*€/year*	*number*	*Van der Aa, 2010:127*
Benefits from regulating services			
From regulation of wastes, pollution & nutrients			
Benefits from N removal by grass buffer strips	*€/ha*year*	*number*	*Jacobs et al., 2010:262*
Benefits from climate regulation			
Benefits from carbon sequestration	*€/ton C*	*number*	*Lettens et al., 2010:68-69*
Benefits from cultural services			
Benefits from recreation services			
Urban residents with access to green space	*%*	*graph*	*Simoens, 2010:146*

3. The status of ecosystem service indicators in Flanders in 2011

3.1. Material and methods

According to Carpenter et al. the MA was constrained by, among other things, a lack of systematic information on stocks, flows and economic values of many ecosystem services. They concluded (p.258) that "although many indicators have been proposed, there is no consensus on a manageably small set that can be consistently applied and that services the needs of decision makers and researchers" (Carpenter et al., 2006). In the subsequent years several articles and reports have tried to take stock of the existing ecosystem service indicators, identify data and knowledge gaps and provide recommendations for indicator development (e.g. (de Groot et al., 2010a; Feld et al., 2009; Layke, 2009; Layke et al., 2012; Mace & Baillie, 2007; Reyers, 2011; ten Brink et al., 2011; UNEP-WCMC, 2011; van Oudenhoven et al., 2012). These assessments have looked at the scope or span of indicator sets, their scientific qualities as well as their communicative abilities. The criteria to assess the scope are typically based on an ecosystem service classification and/or a conceptual framework. This framework may refer to a typology of biomes or ecosystems, a classification of ecosystem services, components of biodiversity, the parts of a DPSIR-framework or a policy strategy. A second criterion commonly used in indicator assessments looks at indicators from a producer perspective, namely data availability and the scientific understanding of underlying ecological, social and economic processes. A third criterion assesses the indicators' 'functional quality' from a consumer perspective, i.e. the ability of the (set of) indicators to convey information (e.g. (Layke, 2009; Layke et al., 2012; Reyers, 2011). (Mace & Baillie, 2007) stress that indicators should be designed with their primary role in mind. In a political setting these roles may vary considerably (cf. section 3.3). Manuals on policy indicators stress that indicators should be developed in a participatory approach with relevant stakeholders, linked to policy strategies and targets (e.g. (Biodiversity Indicators Partnership, 2011; ten Brink et al., 2011; UNEP-WCMC, 2011)). Common in these criteria of functionality is that assessments of indicator quality and of their communicative abilities cannot be walled off from the context in which the indicators are to be used (e.g. scale, policy domain, purpose of use) and from the characteristics of the user (e.g. knowledge with regard to the subject matter). This includes the political context (e.g. position of a stakeholder in a policy debate and his information needs), the socio-economic context (e.g. a period of budget growth vs. budget cuts), the identity and perceived reputation of reporting institutions (e.g. reputation of scientific objectivity or ideological bias), the purpose of the indicator (e.g. programme evaluation, organizational audit, basis for budget proposal, …) or even the personal attributes of members of the target audience (e.g. educational background, professional experiences with indicators, …). For indicators, quality appears to be in the eye of the beholder. (Layke et al., 2012) acknowledge that their assessment is a broad generalization and that the indicator scores contain an element of subjectivity. For instance: When is data collection 'sufficient' to allow mapping using a qualitative scale? When are indicators 'accepted' or 'intuitive'?.

At the time of our analysis (second half of 2011) no explicit policy strategy with regard to ecosystem services had been approved by the Flemish government. We therefore focus our assessment on the scope (i.e. the first of the 3 criteria mentioned above) of a set of indicators that had then been proposed to the Flemish biodiversity policy community. As a reference for the scope of the available indicators we use the systems approach presented in Figure 1. More detailed indicator classes for ecosystems services and benefits *sensu stricto* are based on the CICES-classification that was adapted for Belgium (Haines-Young, 2011; Turkelboom et al., 2012; UNCEEA, 2012). Indicator classes for drivers and pressures were derived from the MA (MA, 2005a).

The indicators were compiled from the texts of two reports presented to the Flemish Government in 2010. One was the Flemish Biodiversity Indicators report. It is compiled on an annual basis by INBO and presents a set of biodiversity indicators defined by the European Commission to monitor progress towards the 2010 biodiversity target (Van Daele et al., 2010). The second report was an exploratory study by ECOBE (University of Antwerp) and INBO, commissioned by the Flemish Agency for Nature and Forest (Jacobs et al., 2010b). This study was the first in Flanders to collect policy relevant knowledge and information of a wide range of ecosystem services on a regional scale.

Since the adoption and communication of the new European biodiversity strategy in 2011 several ecosystem service related research projects have been completed in Flanders and Belgium (e.g. BEES, ECOFRESH, VOTES) or are still underway (e.g. Nature Report, ECOPLAN, Nature Value Explorer). Since these projects were still on-going at the time of our analysis their results are not included here. The rapid and continuing developments in ecosystem services research make assessments of indicators like attempts to paint a moving train. Ecosystem service - related indicators outside the field of biodiversity policy *sensu stricto*, e.g. those presented in the Flemish Environmental Report (MIRA) or in the Flemish Agricultural Report (LARA) have not been included. The assessment therefore is not an attempt at completeness. It rather serves as a 'baseline' to gauge operational readiness within the Flemish biodiversity policy and research agencies in 2011 to monitor and report status and trends of ecosystem services and inform policy makers. The assessment will be repeated over the next years to see whether the knowledge and information base for decision making improves as the new global and European biodiversity strategy towards 2020 and 2050 unfolds itself (C.B.D., 2010; EC, 2011). At the Flemish institutional level this exercise could also help in streamlining indicators with targets for the Flemish 2020 Pact and the next Flemish Environmental Policy Plan in 2015.

3.2. Results

The data collection resulted in a total of 152 indicators, including 24 SEBI-indicators, 59 Flemish regional indicators, 35 proposals for Flemish regional indicators and 34 indicators or proposed indicators at a sub-regional scale (e.g. watershed, municipality, …) (see Table 1 and Annex 1). About two thirds of the indicators are supported by empirical data in the form of graphs, maps or numbers.

One third is presented as a concept, with no data available.

The SEBI-indicators represent the Flemish version of the indicators developed under the 'Streamlining European Biodiversity Indicators' initiative. SEBI intended to provide policy makers with a manageable small set of indicators to monitor progress under the European 2010 Biodiversity Strategy ('Halting the loss of biodiversity by 2010'). They are reported by INBO since 2005 on an annual basis and are thus part of the policy cycle. Some of them directly related to targets of the Flemish Environmental Policy Plans, Minaplan 3 (2003-2007), Minaplan 3+ (2008-2010) and Minaplan 4 (2011-2015). Of the 24 SEBI-indicators 22 are presented as a graph, 1 as a map and 1 as a number.

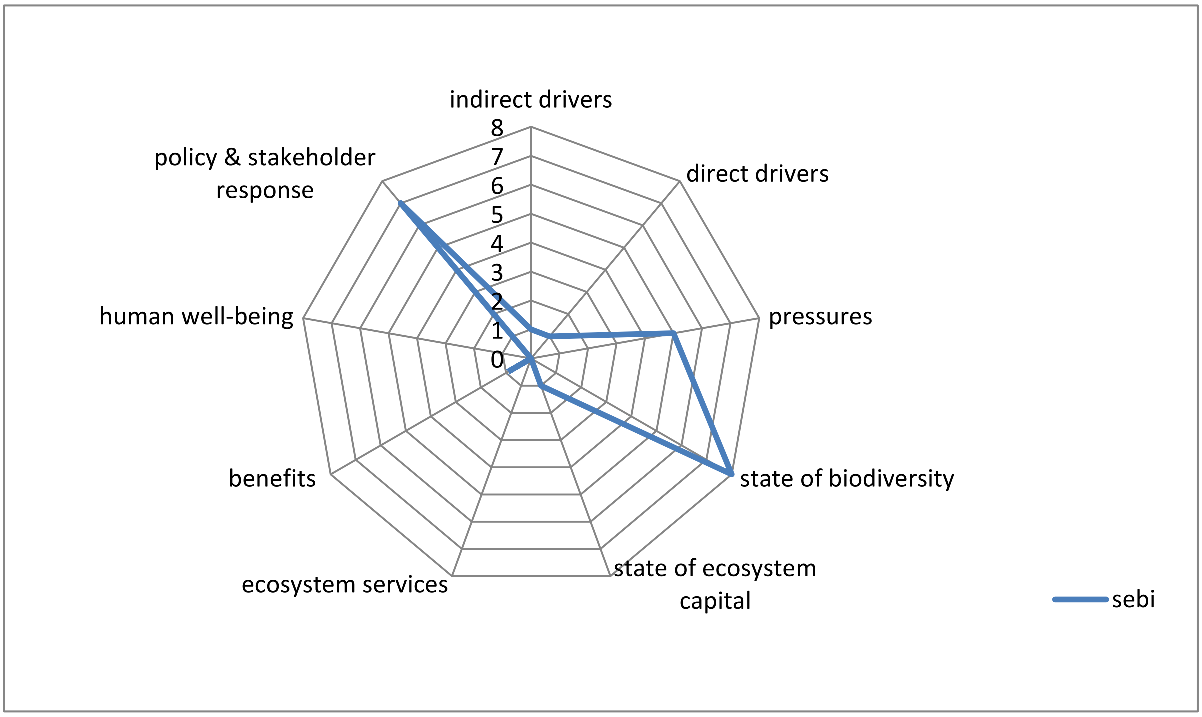
The 59 Flemish regional indicators are at this time not yet reported to policy makers on an annual basis but could be so with some additional work. Twelve were presented as a map, 11 as a graph and 36 as a number or table in a text. If the Flemish government would choose to specify an ecosystem service strategy (e.g. as part of the next Flemish Environmental Policy Plan 2016-2020), or would choose to monitor progress under the new European biodiversity strategy towards 2020, some of these indicators could be taken up in the policy cycle.

The SEBI indicators for which data were available (map, graph or number) reflect a classical pressure/state/response-discourse (see Figure 3(a)). The SEBI-indicators do not really address drivers, ecosystem performance (ecosystem capital, ecosystem services and benefits) or human well-being. These indicators reveal therefore little about the ecosystems' capacity to provide goods and services, and no information about goods and services actually provided. As the 2020- and 2050-targets increasingly focus on aspects of ecosystem performance, the focus of the headline indicators will have to evolve accordingly.

The other regional and local indicators however, collected from (Jacobs et al., 2010) focus much more on (components of) ecosystem performance (see Figure 3(b)). However also in this study no indicators are suggested with regard to drivers, except for production and consumption trends in agriculture and forestry. Also for human well-being no indicators were suggested.

86 out of the 152 indicators or indicator concepts refer to aspects of ecosystem performance, with 33 indicators on benefits, 31 on service output and 22 on ecosystem capital (see Table 1). The ecosystem capital indicators focus on capital stocks rather than on ecosystem processes and functions. Output and benefit indicators refer mostly to to regulating services, with some for provisioning and cultural services. This however can be attributed partly to the larger number of identified regulating services. While the 34 regional ecosystem performance indicators are fairly evenly distributed over ecosystem capital, service output and benefits, the local indicators focus more on benefits than on ecosystem capital and service output.

A total of 34 regional indicators of ecosystem performance may seem a lot and is certainly more than there are SEBI indicators. However, these 34 cover only 5 out of 11 ecosystem service classes, and only 6 out of 9 benefit classes (see Table 1). If we connect the indicators to the 56 ecosystem service types of the Belgian CICES-classification (Turkelboom et al., 2012) then only 4 out of 22 provisioning services and 7 out of 22 regulating services have indicators. For the 12 cultural service classes this analysis was not possible because most of the indicators referred to more than one cultural service (see section 3.3). Also for many of the benefit indicators there was not a direct, 1:1-link with the 56 different service types of the Belgian CICES-classification.



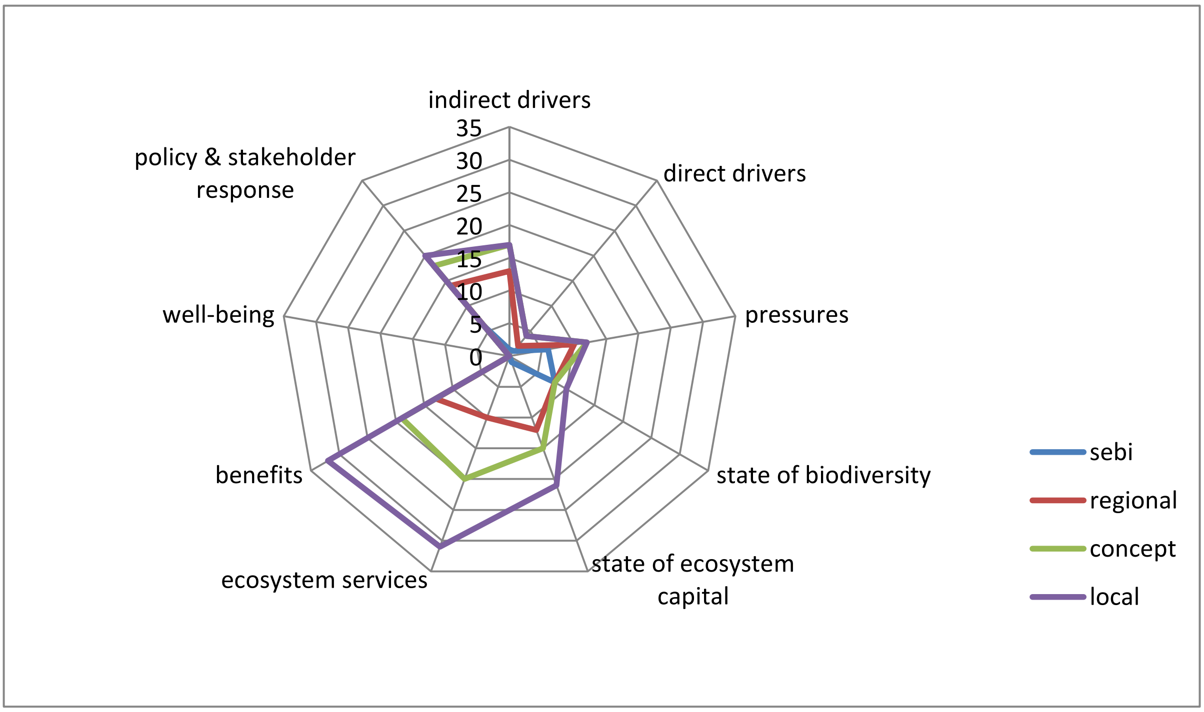


Figure 3. *(a) (above) Focus of the Flemish SEBI-indicators (Van Daele et al., 2010) and (b) (below) of proposed ecosystem service indicators (Jacobs et al., 2010b)*

To conclude, the capacity of the Flemish biodiversity agencies in 2011 to monitor progress towards the ecosystem service targets of the new biodiversity strategy (C.B.D., 2010; EC, 2011) was limited. The available set of indicators still contained important gaps. Also the construct validity of the indicators still needs to be improved. Neither of the two analysed reports contained overall indicators of human well-being, although the benefit indicators address aspects of well-being, for instance in terms of health impact, number of people affected or in monetary terms (see Table 1 and Annex 1).

Table 2. *Overview of Flemish SEBI and ecosystem service indicators (Jacobs et al., 2010b; Van Daele et al., 2010)*

Classification of indicators			**Status of indicators**			
Group	**Section**	**Class**	**SEBI**	**Regional**	**Concept**	**Local**
Indirect Drivers	Demographic		1			
	Economic			12	4	
	Socio-political					
	Science & technology					
	Cultural & religious					
Direct Drivers	Climate change			1	1	
	Invasive species					
	Over-exploitation					
	Pollution & eutrophication					
	Land use change		1		1	
Pressures	Climate change		1			
	Invasive species		1			
	Over-exploitation		1		1	
	Pollution & eutrophication		2	4	1	
	Habitat loss & fragmentation				1	
Biodiversity	Status & trends of the components of biological diversity		8		1	2
Ecosystem Capital & Integrity	Ecosystem processes & functions			3		5
	Natural capital stocks		1	8	4	1
Ecosystem Services	Provisioning services	Nutrition		2		1
		Water supply				
		Materials		4	1	
		Energy				
	Regulation & maintenance services	Regulation of wastes, pollution & nutrients			9	4
		Water & mass flow regulation				6
		Regulation of climate		1		
		Regulation of biotic environment				

	Cultural services	Recreation services		1		
		Experiential services		2	1	
		Intellectual services				
Benefits	From provisioning services	From nutrition		3		
		From water supply				
		From materials		2		
		From energy				
	From regulation & maintenance services	From regulation of wastes, pollution & nutrients		3	2	4
		From water & mass flow regulation			1	6
		From regulation of climate		1		
		From regulation of biotic environment		1	1	
	From cultural services	From recreation, experiential and/or intellectual services	1	3	1	3
Well-being						
Policy & stakeholder strategies & interventions		Territorial measures	6	7	2	2
		Non-territorial measures		1	2	
		Public awareness & participation	1			
		Budget expenditures for biodiversity			1	

3.3. Discussion

3.3.1. Methodological limitations

The method and data used for this case study pose some limitations. By limiting the data collection to the two aforementioned reports, the set of collected indicators does not cover all indicators that were available in Flanders in 2011. Because of the limited data collection there is also some selection bias. The higher count of indicators for regulating services compared to provisioning services may reflect the focus and composition of the research teams (e.g. functioning of hydrological systems, nutrient cycling, carbon sequestration, erosion control, cultural services, …) and the absence of some fields of expertise of provisioning services (e.g. energy, water provision, hunting and wild food, …). The results presented above should therefore be interpreted with some caution.

All of the collected indicators represent single-service indicators. Indicators that synthesize information on trade-offs were not yet included. Nevertheless, informing decisions on the impact of alternative choices in land use or spatial planning (ex ante) or providing accountability of the consequences of these choices (ex post) is one of the areas in which ecosystem services is deemed to be most promising (van Oudenhoven et al., 2012). Although more recent examples exist in Flanders where maps for different services have been juxtaposed, or where ecosystem services and benefits were synthesized in spider graphs, the indicators are still very experimental and evolving (e.g. (Jacobs et al., 2011; Van Der Biest & Jacobs, 2011). These examples usually refer to the local or landscape level. Upscaling this knowledge or finding alternative approaches to inform decision makers at the regional level remains a major challenge.

Besides spatial or sectoral trade-offs, also choices between services and benefits for the current vs. the next generation are part of land use and spatial planning choices. Thus far, benefit indicators based on monetary valuations have been based on the standard 4%-discounting rate (Liekens et al., 2010). Alternative perspectives using declining or negative discount rates have to date received little or no attention in monetary indicators in Flanders (Ochelen & Putzeijs, 2007).

3.3.2. From capital stocks to service flows

In some cases conceptual inconsistencies in the underlying classifications create ambiguity on how to position the indicators in a systems approach or conceptual framework. The CICES-classification operationalizes some of the regulating and cultural services as stocks rather than as flows. For instance, the cultural ecosystem service 'physical and intellectual interactions with ecosystems and landscapes' is operationalized as "area for outdoor activities" (Turkelboom et al., 2012). Similarly, the regulating service 'protection against peak events – natural flood protection & sediment regulation' is operationalized as "natural flood plains & wetlands" (Turkelboom et al., 2012). A similar approach was observed for indicators in ecosystem assessments (Layke et al., 2012). In some cases it may be impractical or too expensive to monitor the actual service output flow. For instance monitoring 'recreation output' would then require counting and surveying vacationers or other people conducting outdoor recreational activities across Flanders and converting these data into 'recreation units'. In the case of peak protection measuring the service would require waiting for an extreme event to assess whether and where the service was actually provided. In these cases a capital stock indicator may be a pragmatic and meaningful alternative. Sometimes it can be assumed or modelled that a higher or different level of natural capital stock (e.g. the extent of a recreation area or natural protective structures) can serve as a proxy for an increased service capacity, potential service use and/or for potential benefits. In those instances measuring and reporting the capital stock can offer pragmatic, credible and useful indicators on the expected service output and benefits. Other examples of such 'stock for service-indicators' can be found in Table 1 and in Annex 1.

There are also instances where the assumed causal relationship between natural capital stock and service output or between service output and benefit cannot be taken for granted. For instance, the same landscapes typically support recreational, social and mental cultural services (see classification in (Turkelboom et al., 2012). Proxy measures based on capital stocks cannot distinguish between these services and implicitly assume that changes in capital stock affect these services evenly. In reality, changes in the capital stock are more likely to trigger uneven changes for different services and service users. If, say, an increase in the recreation area makes it more popular for vacationers during the weekend then it may negatively impact local residents, who appreciate the area for its identity, sense of place or its silence. A stock based indicator may in this case result in a rhetoric of 'more is better' while for some services or some stakeholders the outcome is just the opposite (see also section 1.1). The disconnect between natural capital stocks, ecosystem services and benefits is likely to be stronger in situations where different service users have different perceptions or attach different values to the same capital stock.

3.3.3. From service flows to benefits

Also the causal relationship between output (ecosystem service) and outcome (benefit) is an elusive one. Mainstream ecosystem services literature and manuals that define ecosystem services as "the benefits that people derive from nature", implicitly posit this relationship as an evidence (Costanza, 1997; MA, 2005b). In reality, there may be a certain service output level beyond which the benefit level does not increase further, or even decreases. An on-going increase of the number of visitors in a natural landscape may lead to a congestion of service users, a decrease in the benefit per service user and ultimately in a decrease of the total benefit. Moreover, if the service use exceeds the ecological carrying capacity of the area, then also the capital basis may erode and negatively affect service output and benefits in the future. This knowledge is not new, in fact much of the work in natural resource economics is focused on the relationship between natural capital stocks, sustainable levels of provisioning output and the resulting economic benefits. Indicators like 'maximum sustainable yield' or 'maximum sustainable harvest' remind us that stock, output and outcome indicators are only interchangeable within certain ecological, economic and social boundaries.

3.3.4. From benefits to human well-being

None of the 152 collected indicators directly referred to human well-being. The benefit indicators could be argued to cover at least partly the contribution to human well-being (e.g. monetary value of health benefits). But the 'constituents of well-being', as described in the MA, are not (yet) part of the Flemish biodiversity indicators or indicator concepts. Part of the explanation for this gap are the conceptual challenges in defining clear and unambiguous indicators. Perhaps also the fact that the indicators still largely reflect the knowledge base of the natural sciences, and to some extent that of environmental economics, can explain their absence. Several international organizations and fora compile country indices to capture well-being and economic wealth in a more holistic way than standard macro-economic indicators do. Examples include the net national product (NNP - (Dasgupta & Mäler, 2000)), the index of sustainable economic welfare (ISEW - (Daly & Cobb, 1989)), the genuine progress indicator (GPI - (Lawn, 2003)), the human development index (HDI - http://hdr.undp.org/en/statistics/hdi/) and the happy planet index (HPI - http://www.happyplanetindex.org/). The ISEW has recently been calculated for Flanders and was taken up in the Flemish Environmental Report (MIRA) ((Bleys, 2013) and www.milieurapport.be).

Challenging in the idea of linking well-being trends to (changes in) ecosystems is that well-being is shaped by many factors other than ecosystem changes. Similarly, the benefits associated with ecosystem services do not result from ecosystems alone but from a mix of natural capital, manufactured capital, financial capital, human capital and social capital. Most people conducting outdoor activities of leisure in a natural environment prefer at least some basic infrastructure that facilitates their walks, bike rides or horseback trips in the open. Such infrastructure may suffer from vandalism and may require expensive repairs if there is not enough social capital to treat it with respect. Addressing these knowledge gaps again requires interdisciplinary research, on the part of academics, and intersectoral co-operation on the part of policy workers and stakeholders.

3.3.5. From measurement to management

Performance oriented reforms in public administration and public policy since the early 1980's have introduced a more managerial discourse in the public and not-for-profit sector (Bouckaert & Halligan, 2008). Developing 'smart' result-oriented policy objectives and targets, monitoring progress via indicators and including them in policy plans, budgets, management contracts or evaluation reports, has become a fairly common practice in many policy programmes and policy domains, including environmental and biodiversity policy. Also the idea that measures and indicators increase managerial capacity and improve decision making (cf. "you cannot manage what you do not measure") is still regarded as common managerial knowledge (TEEB, 2008). The fact however that performance measurement and indicators may also pose barriers to improving performance, is often not perceived (Bouckaert, 1995). Strategies of 'gaming' may be set up and individuals or organisations often react strategically to the publication or use of measures and indicators (Van Dooren et al., 2006). This may mean that policy is implemented selectively in a such way that performance scores improve, without necessarily improving policy performance. Alternatively, gaming may also mean that policy targets and indicator definitions are adjusted to what can successfully be reported via performance measures. This results in symbolic or rhetorical performance management practices of 'hitting the target, but missing the point' (Carwardine et al., 2009; Hood, 2006). More measurement of ecosystem performance, then, is not necessarily conducive to better management of ecosystem performance.

3.3.6. From management to policy, politics and power

Management has been defined as "taking responsibility for the performance of a system" (Metcalfe, 1993). Responsibility entails a top-down perspective of control as well as a bottom-up perspective of accountability. In a private sector environment this might refer to control over a production facility or a sales team, and accountability towards a meeting of shareholders or towards the financial market. In a public sector environment this might involve control over a government agency or policy program, or accountability towards a parliament, to the constituency during an election round, or just as well to the financial markets, as recent history has taught us.

The managerial functions of exercising control and establishing accountability require the development and exchange of information (communication). Indicators are developed and used as part of a managerial language of efficiency, control and accountability. This language with symbols and technocratic speech does not only enable agents to give meaning to their managerial communications. By doing so management also imposes a moral order and reveals itself as 'a political activity concerned with the creation, maintenance and manipulation of power' (Bouckaert, 1995). In this 'management of meaning' is decided how performance standards are set and which commitments, rewards or sanctions are attached to them throughout the managerial process. It determines what kind of information is needed and how it should or shouldn't be used. This in turn affects the measurement policy and the meanings derived from these measures. These meanings may be used, misused or abused. The use of measures and indicators reproduces and legitimizes management itself. Being able to legitimize management results in having the power to again define the meaning of management. This is the stage on which performance measures are 'performed'.

It is not uncommon for managerial textbooks and manuals to portray measures and indicators as mere technical tools that allow to register and monitor reality. The typical metaphor is that of a thermometer that clearly and reliably registers and reports the temperature without affecting it.[4] In reality however, measures and indicators are rather the opposite. They are in fact specifically designed to have an impact on that reality. They are used to motivate an organization or stakeholders to pursue and achieve specific organizational objectives and policy targets. They are designed to render accountability and to help establish legitimacy with regard to a certain course of action taken. There is however a fine line between the use of indicators to inform decision makers in a political debate, and using indicators to prove a case. And a fine line indeed between developing and presenting measures that provide accountability about a certain course of action or, on the other hand, presenting them in a way to rationalize and justify it. These political and moral dimensions (e.g. power, legitimacy) of measures and measurement have also important consequences for the definition, development and use of ecosystem service indicators.

3.3.7. Implications for the assessment and development of indicators

Because of the political and normative implications of (ecosystem) performance measurement there is a pressure for data to be used selectively. Examples include the focusing on particular species or species groups, on particular ecosystems or on particular ecosystem services. There is also a danger then for indicators to become ends in themselves, for instance to achieve certain quantified performance levels (e.g. establish x hectare of protected areas) without a clear understanding or policy debate of its significance towards the overall policy goal to which it is to contribute (e.g. halting the loss of biodiversity). Assessments of existing sets of indicators therefore need not only address the question whether their design meets scientific standards of validity, accuracy and reliability and whether they convey their message in a clear and unambiguous way (e.g. (Layke, 2009; Reyers, 2011). They should also pay attention to their use in a managerial/political context (for what purposes are they used?); to the organizational or policy outcomes of this use (do they help to reach policy targets or do they have dysfunctional effects?); and to the power implications of their use (who wins or loses from the use of indicators?).

Context is not only a crucial aspect to consider in assessments of existing

[4] To be correct, a classical quicksilver thermometer does affect the temperature in its environment by using energy from it to expand the volume of the quicksilver, but this impact is so small that it can easily be disregarded.

indicators. Also for the development and adoption of new indicators sufficient attention should be paid to their uses and users. Economists and accountants have since long advocated 'different costs for different purposes'. A similar case has been made with regard to biodiversity indicators (Failing & Gregory, 2003; Mace & Baillie, 2007) and ecosystem service classifications (Fisher et al., 2009). Potential uses and decision contexts of indicators include the evaluation of individual, project, organisational or programme performance; choosing between alternative courses of action; assessing the state of an ecosystem, the flow of services or the distribution of benefits; supporting claims to cut, increase or reallocate budgets; and raising political or public awareness about a certain trend or situation. These purposes need not be mutually exclusive but may partially overlap. At the same time they may compete: indicators that serve one purpose (e.g. informing the general public) are not necessarily fit for another purpose (e.g. assessing organisational performance).

Both assessments of existing indicators and the development of new ones are therefore best embedded in a participatory process. This process should be a cycle that includes an evaluation of how the indicators were used, by whom, and with what consequences, as part of a continuing search for valid, meaningful, functional and legitimate indicators (see Figure 4).

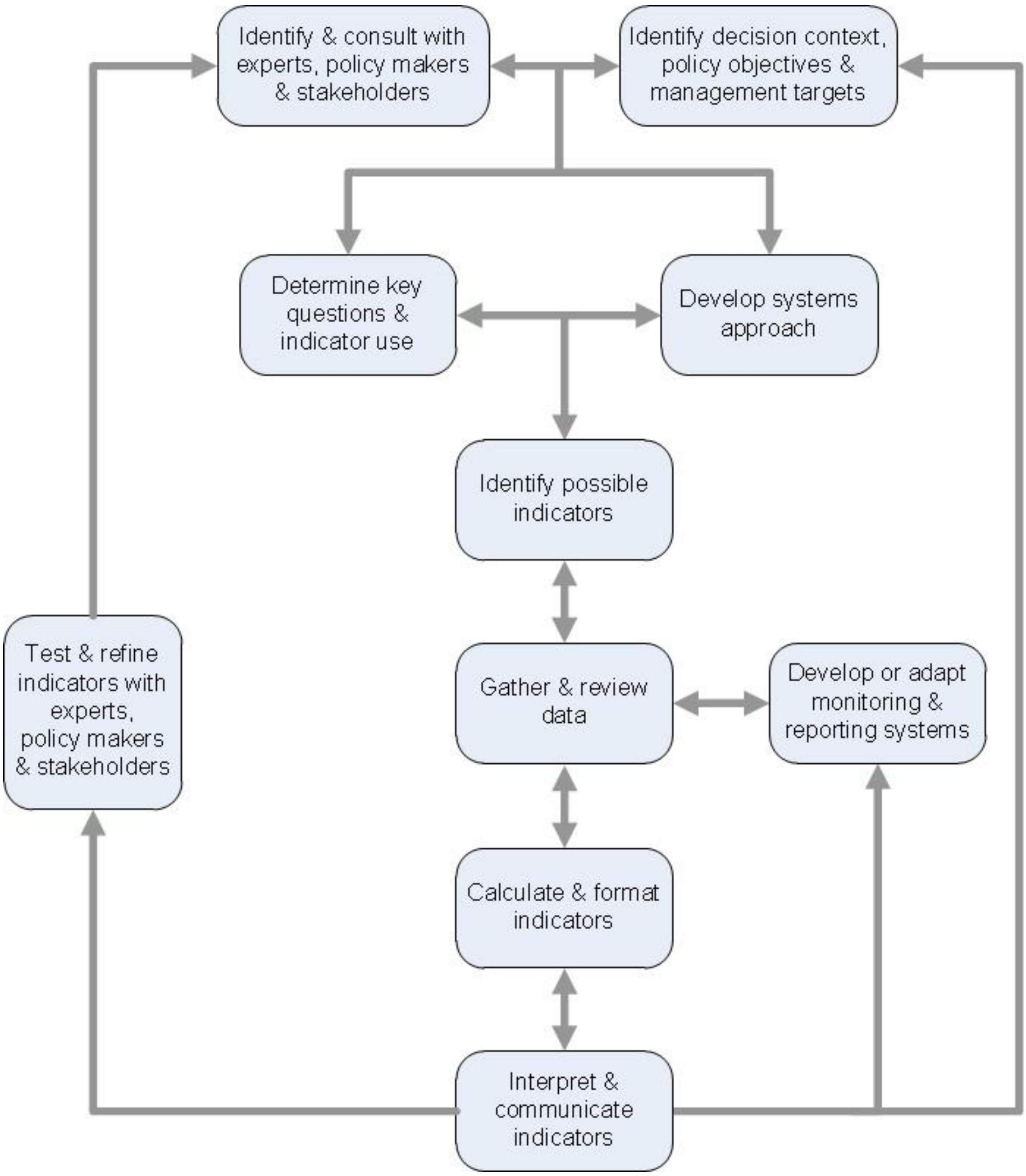


Figure 4. *A stepwise approach for the development, use and assessment of indicators (adapted from Biodiversity Indicators Partnership, www.bipnational.net)*

4. Measuring and managing ecosystem performance

In the new global and European biodiversity strategies a key motivation for the management (and measurement) of ecosystem services is the goal to sustain or restore ecosystems' capacity to deliver goods and services to the current and next generations (C.B.D., 2010; EC, 2011). In the previous sections we referred to this capacity, the actual amount of services delivered and the provided benefits as 'ecosystem performance'.

Does measurement of ecosystem performance necessarily enable a better management or governance of ecosystem performance? With regard to the effects of the use of measures and indicators on management and policy, Bouckaert identified a pathology of 13 'measurement diseases'. They refer to instances where assumptions about indicators or the activity of measurement itself may trigger dysfunctional effects for an organization or a policy programme (Bouckaert, 1995:388-405). This may in some cases trigger a policy outcome that is opposite of what the policy intended in the first place. Here we focus on 10 'diseases' or dysfunctions that may be appear when ecosystem service indicators are developed and used for decision making.

4.1. Measurement pathologies related to the perception of volumes and numbers

- convexity (or concavity) disease: Measurement results in a measured result that is higher (or lower) than the real result. This may result in an overly optimistic or pessimistic perception among the users of the indicator and may trigger potentially exaggerated (or insufficient) decisions. For instance, results based agri-environment schemes for mowing regimes in meadows in the Netherlands were controlled by monitoring the presence of target species. As a result some farmers started to plant some of the target species like Flowering rush (Botumus umbellatus) alongside the ditches in their meadows, to increase the measured outcome. The measured presence of the species was overly optimistic in that the natural conditions for a spontaneous return or increase of the species were not met.

- hypertrophy disease: Measurement leads to an increase of a process component, so that an activity or program diverts from its policy goals. For instance, in a time where climate change is high on the political agenda, a government focussing on the socio-economic benefits of biodiversity policy may decide to motivate carbon sequestration as a goal for nature and forest policy. To the extent that only this ecosystem service (climate regulation) is explicitly measured and reported while data about other ecosystem services or intrinsic values are absent, there may be a pressure to simply maximize a territory's biomass by reforestation or allowing natural succession or even eutrophication. If this is done in a oligotrophic semi-natural ecosystem, like a species-rich hay land or a dry heath vegetation, other services (e.g. pollination) or existing rare habitats and red list species may be disadvantaged, leading to a decline in other services or in biodiversity.

- atrophy disease: Measurement leads to a decrease of a process component, so that an activity or programme diverts from its policy goals. For instance, a focus on quantitative measures of output quantity (e.g. amount of hectare mowed per day; volume of wood harvested per day; area inspected per day) may lead to a deterioration in output quality or in undesirable policy outcomes (e.g. vegetation mowed less carefully, wood harvest increasing ecological damage to forests; faster inspections leading to less violations discovered). The result may be a decrease in biodiversity or in law abiding behaviour. Output quality and outcomes are generally more difficult or more costly to measure than output quantity. Because outcome is often more difficult to control than output, outcome measures are sometime less appealing to decision makers who are held accountable, than output measures. As a result measures of output quality and outcome not always adequately represented in sets of indicators and may may then also be underrepresented in the policy discourse.

4.2. Measurement pathologies related to the measurement itself

- Mandelbrot disease: More measurement or the adoption of new measurement techniques leads to an increase in the perceived frequency of a phenomenon, although in reality the phenomenon has stayed the same. Increasing the number of inspectors to monitor the occurrence of violations of environmental regulations will probably result in an increase of the reported number of violations. This increase rather reflects the increased intensity of measurement than an increased pressure on the environment. The large scale use of new monitoring techniques like photo traps to detect mammals may result in a strong increase of observations of previously undetected animals. If these observations are covered by the press it may create a widespread perception of a significant population increase while the actual population may not have changed that much.

4.3. Measurement pathologies related to the content, number and status of indicators

- pollution disease: Measures and indicators may mix notions of ecosystem capital (stock), service capacity, service demand, use of services and benefits, especially when they are expressed in monetary terms. The economic value of the goods & services (flows) delivered by ecosystems has been used to put a price on the natural capital (stock) which ecosystems represent (Costanza, 1997). This mixing of constructs in one value can be dysfunctional because shifts in the monetary value may reflect shifts in consumer preferences, shifts in the amount of consumers, shifts in ecosystem size and capacity, or combinations of those. Even quantified or monetized measures can thus make specific elements of the society-ecosystem interaction less visible and even opaque. It opens the door to introduce value judgments in the definition of the indicator, gives a lot of power to the technocrats and results in measures that often don't tell anymore where the observed changes come from. A remedy may be to monitor the conflated constructs more separately. This however risks to trigger an inflation of indicators.

- inflation disease: An inflation of indicators may arise out of concern from experts to represent a complex phenomenon (e.g. ecosystem functioning and change) with enough nuance and detail to prevent simplistic or misleading conclusions and 'wrong' decision making. This may result in long lists of indicators which make it difficult to discern the forest between the trees and maintain a policy relevant overview. Moreover, a more lengthy set of indicators is more time consuming and costly to keep up to date. It may also result in 'indicator shopping', selectively using indicators for particular (individual, organizational or political) purposes. It may be preferable to develop a hierarchy of measures (e.g. indicator tree) and make it more function- and user oriented ('different indicators for different purposes'). The headline set of SEBI indicators was an attempt to combine compactness, completeness and complexity. It contained 26 specific indicators, clustered in 16 headline indicators, further reduced to 7 focal areas (EEA, 2009). It contained nevertheless little or no indicators on ecosystem capital, services or benefits (see Figure 3). Adding more indicators may thus lead to inflation.

- enlightened top-bottom disease: Measures or indicators may be introduced hierarchically from the top of an organisation or from outside a community (e.g. nature conservation, farmers, hunters). As a result they may lack ownership, meaning or legitimacy with those whose behaviour the indicators are to monitor or upon whose co-operation they depend for data collection (e.g. indicators to monitor results of agri-environment schemes). They can create distrust, may decrease motivation and may hinder policy implementation. A remedy may be to design a more participatory approach to indicator development between scientists, policy workers and local stakeholders.

- time shortening disease: Measures and indicators may make an organization or policy focus on the short term and on quick wins, rather than on long-term and more fundamental trends. The Flemish policy and management cycle plans, monitors and evaluates along a one, five or six year time frame. However, ecosystem (service) trends may span one or more decades or even centuries. Trends over such an extended time scale may be of little meaning to decision makers who desire to monitor or present results during the interval of their political or managerial tenure. "Performance" in English has a double meaning. On the one hand it refers to how well an organization or policy programme is doing. On the other hand, it has also a more 'theatrical' connotation, suggesting how well it is being presented or performed. The time shortening disease can be, and is, partly remedied by including long term goals in policy plans, by using time series in indicators that span several decades, or by drawing up forward-looking estimates and conducting scenario analyses to help put the indicators in perspective.

- mirage disease: Due to a lack of a precise measure, for instance because of unavailable data or cost considerations, a measure may be replaced by an indicator which only approximates the construct to be measured; in other words, the indicator shows not what we think to perceive but only an image of it. For instance, economics is based on axioms about a large number of self interested, utility maximizing agents in the market. However, the level of utility itself is not measured or monetized directly. Rather, the benefit which consumers of marketed (ecosystem) goods and services receive is inferred from the monetary value (market price) of the traded good or service. The price mechanism thus equates outcomes (utility, value) with outputs (price paid) and conflates effectiveness (output-outcome relationship) with efficiency (input-output relationship). It may further trigger the shifting disease, for instance by making a policy debate focus on outputs instead of outcomes, or on efficiency instead of effectiveness.

- shifting disease: Measures and indicators may not match the goals of an organisation or policy programme. A strict focus on the measures, for instance in planning, budgeting or performance appraisals may make an organization or policy programme shift away from the intended direction. For instance the goal of an acquisition programme in nature policy may be to acquire a certain number of hectare per year. In order to meet the target the competent agency may be tempted to look for those parcels that are most easy to acquire, rather than on the ones where it is deemed most necessary for reasons of conservation (e.g. efficiency of conservation management; effectiveness of connecting large areas; urgency because of conservation status). The result may be that the policy programme meets its output-oriented performance standards (number of hectare per year acquired) but fails to optimize on its goals of biodiversity conservation. A solution may be to include more outcome related criteria into the decision making process.

4.4. Need for pragmatism and dialogue

Ecosystem services and biodiversity fit within a complex chain of constructs and phenomena. Some refer to processes with non-tangible outputs. Shifts in the volume or distribution of these service flows may have very real and tangible outcomes (positive or negative benefits) for individual and collective welfare and well-being. But they may nevertheless be hard to quantify or capture in one single comprehensive measure or even set of indicators that is easily used in a decision making context. Managing without measuring may be flying blindly indeed, which is likely to lead to disaster. Equally true however is that measures and indicators which may seem valid and reliable at first sight, may lack legitimacy among stakeholders whose cooperation is essential, or may yield other dysfunctional policy effects. Assessments of existing sets of ecosystem service indicators conclude that they need to be expanded and improved before they can fully support the use of ecosystem service concepts in policy making (e.g. (Layke, 2009). The list of possible dysfunctions or 'measurement diseases' listed above suggests that indicator development is not exact science. Literature offers no simple recipes or perfect remedies to prevent or cure all measurement diseases. To the contrary, it suggests that sometimes a disease is something that we must and can learn to live with (Bouckaert, 1995). It implicates that indicators of ecosystem performance require some tolerance for ambiguity among those using them, an idea that may fit uneasily in the realm of natural sciences.

It will however be necessary to avoid 'paralysis by analysis' and to put indicators into practice, realising the risks and possible dysfunctions involved. It will require finding a balance between accuracy and simplicity, between reliability and legitimacy, between validity and functionality. It will require linking scientific expertise to practical knowledge, and bridging academic or professional divides between natural sciences, economics, other social sciences. It will require scientists and professionals to look across their academic or professional walls to invite and solicit local or indigenous knowledge. It will also require being explicit about the strengths and limitations of the axioms, values and normative frameworks inherent in the different scientific approaches. A participatory process between these stakeholders, following a cyclic process as presented in Figure 4 appears to be the best way forward to achieve this.

5. Conclusions and recommendations

Recent policy communications at the international, European, federal, regional and local level suggest that restoring, sustaining and exploiting ecosystem performance is going to be part of policy programmes and the focus of policy instruments in the years and perhaps decades to come (EC, 2011). It also seems that measures and indicators will be part of the information that is to support ecosystem management and governance (Layke et al., 2012; MA, 2003; TEEB, 2011). In that case, policy makers and scientists will have to pay attention to the performance of ecosystem performance indicators.

Are we measuring what we want to manage? If the managerial aspiration is one of a society that is able to sustain or restore the planet's ecosystem performance (or that of a smaller region), then Flanders is currently only able to measure this to a limited extent. Our analysis of 152 Flemish indicators indicated that they cover only a minority of our natural capital stocks, ecosystem services and the related benefits. Most indicators lack empirical data or are still in a conceptual stage. The indicators that were available in 2011 also referred to single services. Indicators on synergies and trade-offs between ecosystem services, to support decision making with regard to service bundles, were in 2011 not yet available for policy makers, at least not on a regional level. Also the links between ecosystem services and benefits and their impact on human well-being are not yet covered by the available indicators.

Current indicators often mix natural capital stocks with service flows (output) and benefits (outcome). This can reduce construct validity or may increase the ambiguity of the indicators. An indicator or measure that captures ecosystem health does not reveal the benefits actually enjoyed. An indicator that shows the amount or distribution of benefits does not reveal whether this is sustainable, etcetera (de Groot et al., 2010a; UNEP-WCMC, 2011). Since ecosystem performance constitutes a multi-dimensional and multi-faceted construct, indicators need to distinguish stocks and flows, ecosystem quantity and quality, supply and demand of services, volumes and values and their temporal and spatial distribution between regions or stakeholders .

Policy and governance information systems should emulate this diversity and complexity. Sets of indicators will need to refer to these different dimensions of ecosystem performance, will have to be based on different types of measurement and data analysis, via interdisciplinary and transdisciplinary approaches. There is clearly a tension between the requirement of completeness and thoroughness of understanding, and the need to limit sets of indicators to prevent information overload for users or exuberant costs of data collection.

Constructs are sometimes mixed up in indicator lists because of to fundamental challenges in capturing complex relationships via indicators as well as to practical measurement problems, especially for the non-tangible or immaterial cultural services. Pragmatic solutions have been proposed, although these may result in reduced construct validity or in strategic use of the indicators.

The available indicators still reflect the research focus of particular centres of expertise, leaving several sections of the ecosystem framework blank. In the following years policy agencies and research centres will have to try and broaden the research and knowledge base in order to cover a wider range of ecosystem services as well as their link with human well-being. The current collection of indicators needs to be expanded and improved before it can fully support the use of ecosystem service concepts in policy making. With a significant proportion of the ecosystem services still lacking indicators, the aggregation of information across different services still represents a major challenge. Without such aggregations, indicator sets risk facing the choice between becoming too selective and incomplete, or becoming too exhaustive and overpopulated.

Feld et al. (2009) observed that since the MA, international and national policies have not yet adequately stimulated the development of comprehensive indicator systems suited to detect and measure the state and trends in biodiversity and their implication on ecosystem service provision. This observation also applies to Flanders. An ecosystem service strategy that transcends the separate policy domains may help in providing guidance on priority indicators. In addition to a government-wide approach, more sectoral or thematic policy programs like common agricultural policy, integrated water policy, climate change, protected areas, sustainable urban development, tax and subsidy reform can help prioritize the development of indicators. Capturing the low hanging fruit, by selectively including currently available indicators in policy documents and processes, can help to spark interest and build awareness among policy makers and stakeholders. Reporting processes can serve as a vehicle to convert and improve existing sets of indicators. Figure 4 outlines a stepwise approach for such a process. It would appear wise to heed the advice formulated in the early stages of the MA: "The more involved decision makers and stakeholders are in the selection of indicators, the greater will be their acceptance of results of the assessments" (Millennium Ecosystem Assessment, 2003). At the same time it should be borne in mind that ecosystem performance cannot be entirely captured or wholly explained, let alone be managed, by means of indicators alone. Indicators should therefore be part of a broader knowledge basis that includes and integrates other knowledge types and formats, including (local) stakeholder knowledge, to help explain and understand the observed indicator trends. Indicators however can help in pointing out critical thresholds, can provide early warnings for irreversible changes or suggest general trends which can be used to inform debates in policy and society (MA, 2003). They can also help to point out issues which merit more attention, or consultation with policy implementers or local stakeholders.

Political and strategic use of indicators should probably be regarded as part of standard organizational and policy practice, for indicators represent information used to exercize power and establish legitimacy. This requires some tolerance for ambiguity and subjectivity on the part of the producers of indicators, an idea that may fit uneasily in natural sciences communities. On the other hand, indicator based communications will have to be submitted periodically to more thorough assessments and evaluations. These reviews should not only address the characteristics of indicators themselves, like their statistical validity, their accuracy and their clarity. They should also assess whether their design was sufficiently context specific and whether their application has led to dysfunctional decisions and policy outcomes.

Annex 1 Flemish Ecosystem Service Indicators

This annex lists the 152 indicators for which data were collected from (De Meulenaer & Jacobs, 2010; De Meulenaer et al., 2010a; De Meulenaer et al., 2010b; Jacobs, 2010; Jacobs et al., 2010a; Jacobs et al., 2010c; Lettens et al., 2010; Simoens, 2010a; Simoens, 2010b; Staes et al., 2010a; Staes et al., 2010b; Stragier, 2010; Turkelboom, 2010; Van Daele et al., 2010; Van der Aa, 2010; Van der Biest & Van Ballaer, 2010; Vandevenne, 2010). The status of the indicator (last column) is scored according to the following four classes: 1 = available SEBI-indicator that is used for annual policy reporting; 2 = available indicator on Flemish regional scale, but not part of recurrent policy reporting; 3 = concept of a regional indicator, but not yet available due to lack of data; 4= indicator or concept of indicator at a sub-regional or local scale.

Group	Section	Class	Indicator	Unit	Presenta-tion	Reference	Status
Indirect Drivers	Demographic		Population density	#/km²	number	Van Daele et al., 2010:8	1
	Economic	Energy use	Combustion of fossil fuels	--	text	Staes et al., 2010:83	3
			Share of energy wood in total energy consumption	--	text	Van der Aa, 2010:134	3
		Agriculture & food	Share of bio-products in total Belgian food consumption	%	number	Turkelboom, 2010:109	2
			Number of farms & farmers	#	number	Turkelboom, 2010:113	2
			Growth of average farm area	% hectare	number	Turkelboom, 2010:113	2
			Pollination dependent agricultural activities in Flanders	hectare	map	De Meulenaer et al., 2010:175	2
			Food production partially depending on wild pollination	€	number	De Meulenaer et al., 2010:178	2

		Forrestry & wood	Companies in wood industry	#, %	number	Van der Aa, 2010:123	2
			Jobs in wood industry	#	number	Van der Aa, 2010:123	2
			Share of import & domestic production wood consumption	%	number	Van der Aa, 2010:123	2
			Market size & share for certified forest products and	round-wood eq., %	number	Van der Aa, 2010:127	2
			Market share of certified wood produced in Belgium	%	number	Van der Aa, 2010:127	2
			Share of processed timber wood of Flemish origin	%	number	Van der Aa, 2010:134	2
			Consumption of wood & wood products per capita	--	text	Van der Aa, 2010:134	3
			Import & export of wood and related products	--	text	Van der Aa, 2010:134	3
		Leisure	Share of free time devoted to recreation	%	pie graph	Simoens, 2010:162	2
	Socio-political		---				
	Science & technology		---				
	Poverty		---				
	Cultural & religious		---				
Direct Drivers	Climate change		C- & other GHG-emissions from fossil fuel burning or land use changes	Gton/year	text, figure	Lettens et al., 2010:62-63	3
			Atmospheric concentration of CO2 & other GHG	ppm	text, graph	Lettens et al., 2010:61-63	3
	Invasive species		---				
	Overexploitation		---				

	Pollution & eutrophication	---				
	Land use change	Major land uses in Flanders	hectare	bar graph	Van Daele et al., 2010:9	1
		Population in proximity of coasts & major rivers	%	number	Jacobs et al., 2010:194	3
Pressures	Climate change	Southern-European dragonflies	#	bar graph	Van Daele et al., 2010:20	1
	Invasive species	Alien species	#	trend graph	Van Daele et al., 2010:19	1
	Overexploitation	Ecological footprint of Flanders	hectare, %	pie graph	Van Daele et al., 2010:28	1
		Inhabitants per area of green space	#/m²	text	Simoens, 2010:147,154	3
	Pollution & eutrophication	Extent & sectoral sources of noise hinder	%	bar graph	Stragier, 2010:207	2
		Share of fine dust from anthropogenic sources	%	number	De Meulenaer et al., 2010:222	2
		Contribution of farming to environmental pressue in Flanders	%	bar graph	Turkelboom, 2010:114	2
		Critical load exceedance for nitrogen	kg N/ ha.yr	trend graph	Van Daele et al., 2010:18	1
		Nitrogen deposition	--	text	Staes et al., 2010:83,96	3
		Nutrient (N,P) supply via land & rivers	kg/ km².yr	number	Vandevenne, 2010:45,56	2
		Nitrogen residue in agricultural soils	kg N/ ha.yr	trend graph	Van Daele et al., 2010:24	1
	Habitat loss & fragmentation	Connectivity/fragmentation of terrestrial ecosystems	--	text	Van Daele et al., 2010:6	3

Biodiversity	Status & trends of the components of biological diversity		Common breeding bird abundance	index	trend graph	Van Daele et al., 2010:10	1
			Conservation status of birds of European importance	index	bar graph	Van Daele et al., 2010:14	1
			Common grassland butterfly abundance	index	graph	Van Daele et al., 2010:11	1
			Overwintering waterfowl abundance	index	graph	Van Daele et al., 2010:12	1
			Red list species status	classes	pie & bar graph	Van Daele et al., 2010:13	1
			Conservation status of species of European interest	classes	pie & bar graph	Van Daele et al., 2010:14	1
			Conservation status of habitats of European interest	classes	pie & bar graph	Van Daele et al., 2010:15	1
			Area of high nature value farmland	%	map	Van Daele et al., 2010:25	1
			Genetic diversity of domesticated animals, cultivated plants, fish species and trees of major socio-economic importance		text	Van Daele et al., 2010:6	3
			Biological value	classes	map	Jacobs et al., 2010:283	4
			Potential of habitats of European interest	classes	map	Jacobs et al., 2010:283-284	4
Ecosystem Capital & Integrity	Ecosystem processes & functions	Functioning of hydrological systems	Infiltration potential of soil	classes	map	Staes et al., 2010:28	2
			Water retention potential	classes	map	Staes et al., 2010:30	2
			Water storage potential	classes	map	Staes et al., 2010:32	2

	Nutrient cycling	Nutriënt balance in estuaries (N:Si:P-ratios)	ratio	graph	Vandevenne, 2010:45	4
		Benthic & pelagic denitrification in estuaries	mmolN/m³.d	graph	Vandevenne, 2010:48	4
		Si-cycling via sedimentation & biomass	--	text	Vandevenne, 2010:49	4
		Frequency of Si-limitation	months/yr	number	Vandevenne, 2010:56	4
		Annual biomass of diatoms & Phaeocystis sp. in coastal zone	--	table	Vandevenne, 2010:57	4
Natural capital stocks		Change in carbon stock in soil/vegetation of ecosystems via drivers or policy response	ton C/ha	map/text/ number	Lettens et al., 2010:61, 65-66, 70-71	2
		C/N-ration (carbon balance) in ecosystems (soil, organic material, vegetation)	--	text	Staes et al., 2010:83, 86-87	3
		Ground water level	--	text	Staes et al., 2010, 89	3
		Soil loss on farmland	m³/yr	text	Jacobs et al., 2010:259	4
		Phosphorus concentrations in rivers	classes	bar graph	Van Daele et al., 2010:22	1
		NO_3, NH_4 & PO_4 concentrations in rivers	classes	map	Staes et al., 2010:80	2
		N & P stock in biomass of ecosystems	g or kg N,P/ ton	graph & tekst	Staes et al., 2010:85-86	3
		Soil suitability for tree species	classes	map	Van der Aa, 2010:130	2
		Forest cover of Flanders	%	number	Van der Aa, 2010:125, 128	2

			Standing wood stock (volume, species, age)	m³, m³/ha, ha	number, graph	Van der Aa, 2010:124-125, 129	2
			Standing wood stock (current market value)	€	number	Van der Aa, 2010:128	2
			Marine trophic index	--	text	Van Daele, 2010:6	3
			Area of protective natural structure along coast & tidal rivers	hectare	number	Jacobs et al., 2010:195	2
			Average annual PM10 concentration	µg/m³	map	De Meulenaer et al., 2010:223	2
Ecosystem Services	Provisioning services	Nutrition	Crop production	ton/yr	number	Turkelboom, 2010:112	2
			Cattle production	#	number	Turkelboom, 2010:112	2
			Provisioning services in the coastal zone from improved nutrient cycling in rivers	--	text	Vandevenne, 2010:54	4
		Water supply	---				
		Materials	Sustainable timber harvest		text	Van der Aa, 2010:124,126	3
			Timber harvest	m³	bar graph	Van der Aa, 2010:126	2
			Logging intensity	m³/ha	bar graph	Van der Aa, 2010:127	2
			FSC-certified wood sold	m³	number	Van der Aa, 2010:127	2
			Certified wood products sold on Belgian market	m³ round-wood eq.	number	Van der Aa, 2010:127	2

	Energy	---				
Regulation & maintenance services	Regulation of wastes, pollution & nutrients	Potential denitrification in the Nete watershed	mg NO3/l	map	Staes et al., 2010:81	4
		Nitrate retention capacity of/ Nitrification in / Nitrate leaching from forests	--	text	Staes et al., 2010:83	3
		Relative N-removal in marshes and lakes	%	graph	Staes et al., 2010:92	3
		Denitrification in soils of rivers, in alluvial sois	g N/ m²*mont h	text, graph	Staes et al., 2010:93-94	3
		Denitrification in riparian ecosystems	--	text	Staes et al., 2010:98	3
		P-retention in water soils	kg/ha.yr	number	Staes et al., 2010:101	3
		P-retention by buffer strips and riparian zones	%	number	Staes et al., 2010:102	3
		P & organic N sequestration via sedimentation & biomass	--	text	Vandevenne, 2010:48	4
		Nutrient removal (N,P) in estuaries	kg/ha.yr	table	Vandevenne, 2010:53	4
		N removal by grass buffer strips in farmland	kg N/ha.yr	number	Jacobs et al., 2010:262	4
		Fine dust capture by nature types	kg/ha.yr	table	De Meulenaer et al., 2010:229-230	3
		NO_x & NH_3 capture by nature types	kg/ha.yr	table	De Meulenaer et al., 2010:230-231	3
		Noise absorption by dense forest vegetation	dB/hm	table	Stragier, 2010:218	3

		Water & mass flow regulation	Frequency of muddy floods	#/yr	map	Jacobs et al., 2010:261	4
			Reduced soil loss due to no tillage ploughing & grass lanes	%	number, text	Jacobs et al., 2010:251,259,260	4
			Capture of eroded sediment	m³, %	graph	Jacobs et al., 258	4
			Reduced runoff of rain water due to no tillage plouging	%	text	Jacobs et al., 2010:251	4
			Reduction of peak discharge	m³/s, %	graph	Jacobs et al., 2010:259	4
			Reduction of sediment supply to built area and water courses	--	text	Jacobs et al., 2010:260	4
		Regulation of climate	C uptake by oceans, soil, terrestrial vegetation (per policy measure)	Gton/yr, ton/ha.yr	number, figure	Lettens et al., 2010:62-64; Jacobs et al., 2010:262	2
		Regulation of biotic environment ---					
	Cultural services	Recreation services	Supply of green space for recreation	% land use	map	Simoens, 2010:144	2
			Vicinity of green space for built area	m	map	Simoens, 2010:145	2
			Supply of green space per inhabitant	m²/inhabi-tant	bar graph	Simoens, 2010:146,268	2
		Experiential services ---					
		Intellectual services ---					
Benefits	From provisioning services	From nutrition	Agricultural & horticultural production value	€	trend graph	Turkelboom, 2010:112-113	2
			Net added value of agricultural & horticultural activity	€	number	Turkelboom, 2010:112	2

		Income from farming per working family member	€/year	number	Turkelboom, 2010:113	2
	From water supply	---				
	From materials	Timber harvest	€/year	number	Van der Aa, 2010:127	2
		Turnover of timber industry in Belgium	€/year	number	Van der Aa, 2010:123	2
		Percentage of European patent applications for inventions based on genetic resources	--	text	Van Daele et al., 2010:6	3
	From energy	---				
From regulation & maintenance services	From regulation of wastes, pollution & nutrients	Benefits of N removal by grass buffer strips	€/ha.yr	number	Jacobs et al., 2010:262	4
		Benefits of nutrient (N,P) removal	€/ha.yr	graph	Vandevenne, 2010:51	2
		Benefits of nutrient (N,P) removal in estuaries	€/ha.yr	table	Vandevenne, 2010:53	4
		Marginal cost of N removal	€/kg	graph	Staes et al., 2010:104	4
		Marginal cost of P removal	€/kg	graph	Staes et al., 2010:104	4
		Benefits of capture of fine dust, NO_x & NH_3 by nature types	€/kg	table	De Meulenaer et al., 2010:232	3
		Disability adjusted life years from exposure to fine dust	monts/ person	number	De Meulenaer et al., 2010:221	2
		% of population experiencing noise hinder	%	map, table	Stragier, 2010:206-207	2
		Change in real estate prices by noise reduction	% dB	table	Stragier, 2010:219	3

From water & mass flow regulation	Gross benefits of natural coastal protection (npv of avoided costs)	€	number	Jacobs et al., 2010:197-198	4
	Net benefits of flood protection measures (npv of avoided costs, reimbursement time)	€, yr	number	Jacobs et al., 2010:199	4
	Number of people suffering from coastal floods	#/yr	number	Jacobs et al., 2010:194	3
	Net benefits of erosion prevention measures (avoided damage - production loss)	€	text	Jacobs et al., 2010:250	4
	Costs of erosion (property damage costs, soil loss costs)	€	text	Jacobs et al., 2010:251	4
	Benefits of erosion prevention measures (avoided costs, reimbursement time)	€/ha.yr, yr	graph	Jacobs et al., 2010:260	4
	Fire brigade interventions due to floods	number	graph	Jacobs et al., 2010:260	4
From regulation of climate	Benefits of carbon sequestration	€/ton C, €/ha	number	Lettens et al., 2010:61,68-69; Jacobs et al., 2010:262	2
From regulation of biotic environment	Benefits of natural pest control		text	De Meulenaer et al., 2010:167-169	3
	Economic importance of wild pollination	€/yr, €/capita.yr	text	De Meulenaer et al., 2010:178	2

	From cultural services	From recreation, experiential and/or intellectual services	Recreational benefits in nature areas along the Scheldt river	€/visit	number	Vandevenne, 2010:54	4
			Recreational value of forest	€/yr	number	Van der Aa, 2010:140	4
			Frequency of visits to forest and nature areas	classes	bar graph	Van Daele et al., 2010:29	1
			Urban residents with access to green space	%	bar graph	Simoens, 2010:146	2
			Number of anglers in public & private waters	#	number	Van der Biest et al., 2010:184	2
			Turnover of recreational fishing	€/yr	number	Van der Biest et al., 2010:184	2
			Benefits of nursery function (avoided cost of fish placements for anglers)	€/yr	text	Van der Biest et al., 2010:187	3
			Existance & bequest value of additional flood areas by Sigmaplan	€/house-hold	number	Vandevenne, 2010:55	4
Well-being			---				
Policy & stakeholder strategies & interventions	Territorial measures	Coverage of protected areas	Area under conservation management	hectare, %	graph	Van Daele et al., 2010:16;	1
			Sites designated under the Habitat and Bird Directives	hectare, %	graph	Van Daele et al., 2010:17;	1

	Area of forest, farmland, fishery and aquaculture ecosystems under sustainable management	Forest area with sustainable forest management plan	hectare	graph	Van Daele et al., 2010:23	1
		Priority of timber production in Flemish forests	%	graph	Van der Aa, 2010:125	2
		Forest area with FSC certificate & ownership	hectare, %	number	Van der Aa, 2010:127	2
		Area with agri-environmental measures that support biodiversity	hectare, %	trend graph	Van Daele et al., 2010:26	1
		Area under organic farming	hectary, %	trend graph	Van Daele et al., 2010:27	1
	Other territorial measures	Promotion of land use changes in ecosystems with low carbon stocks	--	text	Lettens et al., 2010:62	3
		Prevention of land use changes in ecosystems with high carbon stocks	--	text	Lettens et al., 2010:62	3
		Defragmentation of rivers	%	trend graph	Van Daele et al., 2010:21	1
		Area of bufferstrips in cropland	hectare	number	Jacobs et al., 2010:252	4
		Restored intertidal areas	hectare	text	Vandevenne, 2010:56	4
		Area of protective natural structures created / restored along coast & tidal rivers	hectare	number	Jacobs et al., 2010:195	2
Non-territorial measures		Number of bio-products in cattle sector & subsectors	%	number	Turkelboom, 2010:109	2
		Number of bio farms	#	number	Turkelboom, 2010:109	2

	Reduction of activities that release carbon in the atmosphere	--	text	Lettens et al., 2010:61	3
	Emission reductions by industry, transport, agriculture & households	%	text	Lettens et al., 2010:62	3
	Reduction of GHG emissions by policy measures	%	number	Lettens et al., 2010:70	2
Government expenditures & revenues	Funding to biodiversity	€	text	Van Daele et al., 2010:6	3
	Funding for agri-environment measures	€	number	Turkelboom, 2010:115	2
	Income subsidies and agri-environment subsidies for farmers	€, %	number	Turkelboom, 2010:112, 115	2
Public awareness & participation	Membership of NGO for nature conservation	#	trend graph	Van Daele et al., 2010:30	1

Annex 2 List of abbreviations

ANB	Agentschap voor Natuur en Bos (Agency for Nature and Forest)
COP	conference of the parties
DPSIR	drivers, pressure, state, impact, response
ECOBE	Ecosysteembeheer (Ecosystem Management Group), University of Antwerp
GHG	greenhouse gasses
INBO	Instituut voor Natuur- en Bosonderzoek (Research Institute for Nature and Forest)
LARA	Landbouwrapport (Agricultural Report)
LNE	Leefmilieu, Natuur en Energie (Environment, Nature and Energy)
MIRA	Milieurapport (Environment Report)
NARA	Natuurrapport (Nature Report)
SEBI	Streamlining European Biodiversity Indicators
SMART	specific, measurable, accepted, realistic, time-specific
TEEB	The Economics of Ecosystems and Biodiversity
VRIND	Vlaamse Regionale Indicatoren (Flemish Regional Indicators)

References

Biodiversity Indicators Partnership. (2011). Guidance for national biodiversity indicator development and use. Cambridge, UK: UNEP World Conservation Monitoring Centre,.

Bleys B. (2013). De Index voor Duurzame Economische Welvaart (ISEW) voor Vlaanderen 1990-2011. Gent: Hogeschool Gent.

Bouckaert G. (1995). Improving performance measurement. In: Halachmi A., Bouckaert G. (editors). The enduring challenges in public management Surviving and excelling in a changing world. San Francisco, CA: Jossey-Bass. p 379-412.

Bouckaert G., Halligan J. (2008). Managing Performance: International Comparisons. New York: Routledge.

Braat L., ten Brink P., Bolt K., Braeuer I., ten Brink B., Chiabai A., Ding H., Gerdes H., Jeuken M., Kettunen M. et al. (2008). The cost of policy inaction: The case of not meeting the 2010 biodiversity target. Wageningen. 1718.

C.B.D. (2010). Strategic Plan for Biodiversity 2011 - 2020 and the Aichi Targets: Living in Harmony with Nature. Montreal, Canada.

Carpenter S.R., Defries R., Dietz T., Mooney H.A., Polasky S., Reid W.V., Scholes R.J. (2006). Millennium Ecosystem Assessment: Research needs. Science 314:257-258.

Carwardine J., Klein C.J., Wilson K.A., Pressey R.L., Possingham H.P. (2009). Hitting the target and missing the point: target-based conservation planning in context. Conservation Letters 2:3-10.

Costanza R. (1997). The value of the world's ecosystem services and natural capital. Nature 387:253-260.

Costanza R., Daly H.E. (1992). Natural Capital and Sustainable Development. Conservation Biology 6(1):37-46.

Daily G.C. (1997). Nature's Services: Societal Dependence on Natural Ecosystems. Washington: Island Press.

Daily G.C. (2000). Management objectives for the protection of ecosystem services. Environmental Science & Policy 3(6):333-339.

Daly H.E., Cobb J. (1989). For the common good. Redirecting the economy toward community, the environment and a sustainable future Boston: Beacon Press.

Dasgupta P., Mäler K.-G. (2000). Net national product, wealth and social well-being. Environment and Development Economics 5(1&2):69-93.

de Groot R.S., Alkemade R., Braat L., Hein L., Willemen L. (2010a). Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. Ecological Complexity 7(3):260-272.

de Groot R.S., Fisher B., Christie M., Aronson J., Braat L., Gowdy J.M., Haines-Young R., Maltby E., Neuville A., Polasky S. et al. (2010b). Integrating the ecological and economic dimensions in biodiversity and ecosystem service valuation. In: Kumar P. (editor). The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations. London: Earthscan. p 9-40.

De Meulenaer B., Jacobs S. (2010). Natuurlijke pestcontrole. In: Jacobs S., Staes J., De Meulenaer B., Schneiders A., Vrebos D., Stragier F., Vandevenne F., Simoens I., Van Der Biest K., Lettens S. et al. (editors). Ecosysteemdiensten in Vlaanderen: Een verkennende inventarisatie van ecosysteemdiensten en potentiële ecosysteemwinsten. Antwerpen: Universiteit Antwerpen - Ecosystem Management Research Group ECOBE. p 166-173.

De Meulenaer B., Jacobs S., Staes J., Vrebos D. (2010a). Natuurlijke Pollinatie. In: Jacobs S., Staes J., De Meulenaer B., Schneiders A., Vrebos D., Stragier F., Vandevenne F., Simoens I., Van Der Biest K., Lettens S. et al. (editors). Ecosysteemdiensten in Vlaanderen: Een verkennende inventarisatie van ecosysteemdiensten en potentiële ecosysteemwinsten. Antwerpen: Universiteit Antwerpen - Ecosystem Management Research Group ECOBE. p 174-181.

De Meulenaer B., Staes J., Jacobs S. (2010b). Opname van fijn stof en polluenten door groenelementen in Vlaanderen. In: Jacobs S., Staes J., De Meulenaer B., Schneiders A., Vrebos D., Stragier F., Vandevenne F., Simoens I., Van Der Biest K., Lettens S. et al. (editors). Ecosysteemdiensten in Vlaanderen: Een verkennende inventarisatie van ecosysteemdiensten en potentiële ecosysteemwinsten. Antwerpen: Universiteit Antwerpen - Ecosystem Management Research Group ECOBE. p 221-236.

Departement LNE. (2011). Milieubeleidsplan 2011-2015. Brussel: Departement Leefmilieu, Natuur en Energie, Vlaamse Regering.

Dunn R.R. (2010). Global mapping of ecosystem disservices: The unspoken reality that nature sometimes kills us. Biotropica 42(5):555-557.

EC. (2011). Our life insurance, our natural capital: an EU biodiversity strategy to 2020. Communication from the Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions. COM(2011) 244 final.

EEA. (2009). Progress towards the European 2010 biodiversity target. Copenhagen: European Environment Agency.

Elmqvist T., Maltby E., Barker T., Mortimer M., Perrings C., Aronson J., de Groot R.S., Fitter A., Mace G.M., Norberg J. et al. (2010). Biodiversity, Ecosystems and Ecosystem Services. In: Kumar P. (editor). The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations. London: Earthscan. p 41-111.

Failing L., Gregory R. (2003). Ten common mistakes in designing biodiversity indicators for forest policy. Journal of Environmental Management 68(2):121-132.

Feld C.K., da Silva P.M., Sousa J.P., de Bello F., Bugter R., Grandin U., Hering D., Lavorel S., Mountford O., Pardo I. et al. (2009). Indicators of biodiversity and ecosystem services: a synthesis across ecosystems and spatial scales. Oikos 118(12):1862-1871.

Fisher B., Turner R.K., Morling P. (2009). Defining and classifying ecosystem services for decision making. Ecological Economics 68:643-653.

Haines-Young R.P., Marion. (2011). Common International Classification of Ecosystem Services (CICES): 2011 update: Paper prepared for discussion at the expert meeting on ecosystem accounts organised by the UNSD, the EEA and the World Bank, London, December 2011. Centre for Environmental Management, University of Nottingham, UK.

Halachmi A., Bouckaert G. (1996). Organizational performance and measurement in the public sector. Toward service, effort and accomplishment reporting. Westport, CT: Quorum.

Hatry H.P. (1999). Performance measurement. Getting results: Urban Institute.

Heywood V.H., Watson R.T. (1995). Global biodiversity assessment. Cambridge, MA, USA; New York, NY, USA; Melbourne, Australia: Cambridge University Press.

Hood C. (2006). Gaming in targetworld: The targets approach to managing British public services. Public Administration Review 2006(July/August):515-521.

Institute W.R. (2009). Ecosystem Service Indicators Database.

Jacobs S. (2010). SIGMA Grote Nete. In: Jacobs S., Staes J., De Meulenaer B., Schneiders A., Vrebos D., Stragier F., Vandevenne F., Simoens I., Van Der Biest K., Lettens S. et al. (editors). Ecosysteemdiensten in Vlaanderen: Een verkennende inventarisatie van ecosysteemdiensten en potentiële ecosysteemwinsten. Antwerpen: Universiteit Antwerpen - Ecosystem Management Research Group ECOBE. p 279-286.

Jacobs S., Genar O., Turkelboom F. (2010a). Erosiebestrijding in het bekken van de Melsterbeek. In: Jacobs S., Staes J., De Meulenaer B., Schneiders A., Vrebos D., Stragier F., Vandevenne F., Simoens I., Van Der Biest K., Lettens S. et al. (editors). Ecosysteemdiensten in Vlaanderen Een verkennende inventarisatie van ecosysteemdiensten en ecosysteemwinsten. Antwerpen: Universiteit Antwerpen,. p 250-266.

Jacobs S., Staes J., De Meulenaer B., Schneiders A., Vrebos D., Stragier F., Vandevenne F., Simoens I., Van Der Biest K., Lettens S. et al. (2010b). Ecosysteemdiensten in Vlaanderen. Een verkennende inventarisatie van ecosysteemdiensten en potentiële ecosysteemwinsten. ECOBE 010-R127.

Jacobs S., Van der Biest K., Temmerman S. (2010c). Vermijden van overstromingen. In: Jacobs S., Staes J., De Meulenaer B., Schneiders A., Vrebos D., Stragier F., Vandevenne F., Simoens I., Van Der Biest K., Lettens S. et al. (editors). Ecosysteemdiensten in Vlaanderen: Een verkennende inventarisatie van ecosysteemdiensten en potentiële ecosysteemwinsten. Antwerpen: Universiteit Antwerpen - Ecosystem Management Research Group ECOBE. p 193-204.

Jacobs S., Vandevenne F., Stragier F., Meire P. (2011). Ecosysteemdiensten in de Zwinstreek. Verkennende studie in het kader van het project 'Recreatie & Ecotoerisme in de Zwinstreek' (REECZ). Antwerpen: Universiteit Antwerpen, Ecosystem Management Research Group. ECOBE 011-R142. 136 p.

Kremen C. (2005). Managing ecosystem services: what do we need to know about their ecology? Ecology Letters 8:468-479.

Lawn P.A. (2003). A theoretical foundation to support the Index of Sustainable Economic Welfare (ISEW), Genuine Progress Indicator (GPI) and other related indexes. Ecological Economics 44.

Layke C. (2009). Measuring nature's benefits: A preliminary roadmap for improving ecosystem service indicators. Washington D.C.

Layke C., Mapendembe A., Brown C., Walpole M., Winn J. (2012). Indicators from the global and sub-global Millennium Ecosystem Assessments: An analysis and next steps. Ecological Indicators 17(0):77-87.

Lettens S., De Vos B., Staes J., Jacobs S. (2010). Opslag van koolstof in ecosystemen. In: Jacobs S., Staes J., De Meulenaer B., Schneiders A., Vrebos D., Stragier F., Vandevenne F., Simoens I., Van Der Biest K., Lettens S. et al. (editors). Ecosysteemdiensten in Vlaanderen Een verkennende inventarisatie van ecosysteemdiensten en potentiële ecosysteemwinsten. Antwerpen: Universiteit Antwerpen. p 61-76.

Liekens I., Schaafsma M., Staes J., Brouwer R., De Nocker L., Meire P. (2010). Economische waardering van ecosysteemdiensten, een handleiding. Brussel.

Luck G.W., Harrington R., Harrison P.A., Kremen C., Berry P.M., Bugter R., Dawson T.P., de Bello F., Diaz S., Feld C.K. et al. (2009). Quantifying the Contribution of Organisms to the Provision of Ecosystem Services. Bioscience 59(3):223-235.

Lyytimäki J., Sipilä M. (2009). Hopping on one leg - The challenge of ecosystem disservices for urban green management. Urban forrestry & urban greening 8:309-315.

MA. (2003). Ecosystems and Human Well-Being: A Framework for Assessment. Washington D.C.

MA. (2005a). Chapter 1: MA Conceptual Framework. In: Millennium Ecosystem Assessment (editor). Ecosystems and human well-being Volume 1: Current state and trends. Washington D.C.: Island Press. p 25-36.

MA. (2005b). Ecosystems and Human Well-being: Synthesis. Washington D.C.

Mace G.M., Baillie J.E.M. (2007). The 2010 Biodiversity Indicators: Challenges for Science and Policy. Conservation Biology 21(6):1406-1413.

McMichael A., Scholes R.J., Hefny M., Pereira E., Palm C., Foale S. (2005). Linking ecosystem services and human well-being. In: MA (editor). Ecosystems and Human well-being Volume 4: Multiscale assessments. Washington D.C.: Island Press. p 43-60.

Metcalfe L. (1993). Public management: from imitation to innovation. In: Kooiman J. (editor). Modern governance New government-society interactions. London: Sage. p 173-189.

Müller F., Burkhard B. (2012). The indicator side of ecosystem services. Ecosystem Services 1(1):26-30.

O.E.C.D. (1993). Public management developments. Survey 1993. Paris.

O.E.C.D. (1995). Public management developments. Update 1995. Paris.

Ochelen S., Putzeijs B. (2007). Milieubeleidskosten. Begrippen en berekeningsmethoden. Brussel.

Reyers B. (2011). Measuring biophysical quantities and the use of indicators. In: Kumar P. (editor). The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations. London: Earthscan. p 113-147.

Schneiders A. (2015). De rol van biodiversiteit in de levering van ecosysteemdiensten. In: Stevens M., Demolder H., Jacobs S., Schneiders A., Van Gossum P., Van Reeth W., Peymen J. (editors). Natuurrapport - Toestand en trend van ecosystemen en ecosysteemdiensten in Vlaanderen Technisch Rapport. Brussel: Instituut voor Natuur- en Bosonderzoek.

Simoens I. (2010a). Groen in de stad. In: Jacobs S., Staes J., De Meulenaer B., Schneiders A., Vrebos D., Stragier F., Vandevenne F., Simoens I., Van Der Biest K., Lettens S. et al. (editors). Ecosysteemdiensten in Vlaanderen: Een verkennende inventarisatie van ecosysteemdiensten en potentiële ecosysteemwinsten. Antwerpen: Universiteit Antwerpen - Ecosystem Management Research Group ECOBE. p 267-278.

Simoens I. (2010b). Groene ruimte voor recreatie. In: Jacobs S., Staes J., De Meulenaer B., Schneiders A., Vrebos D., Stragier F., Vandevenne F., Simoens I., Van Der Biest K., Lettens S. et al. (editors). Ecosysteemdiensten in Vlaanderen: Een verkennende inventarisatie van ecosysteemdiensten en potentiële ecosysteemwinsten. Antwerpen: Universiteit Antwerpen - Ecosystem Management Research Group ECOBE. p 142-165.

Staes J., Jacobs S., Vrebos D. (2010a). Cyclering van stikstof en fofor in ecosystemen. In: Jacobs S., Staes J., De Meulenaer B., Schneiders A., Vrebos D., Stragier F., Vandevenne F., Simoens I., Van Der Biest K., Lettens S. et al. (editors). Ecosysteemdiensten in Vlaanderen: Een verkennende inventarisatie van ecosysteemdiensten en potentiële ecosysteemwinsten. Antwerpen: Universiteit Antwerpen - Ecosystem Management Research Group ECOBE. p 77-106.

Staes J., vrebos D., Jacobs S. (2010b). Ecosysteemdiensten uit hydrologische processen. In: Jacobs S., Staes J., De Meulenaer B., Schneiders A., Vrebos D., Stragier F., Vandevenne F., Simoens I., Van Der Biest K., Lettens S. et al. (editors). Ecosysteemdiensten in Vlaanderen: Een verkennende inventarisatie van ecosysteemdiensten en potentiële ecosysteemwinsten. Antwerpen: Universiteit Antwerpen - Ecosystem Management Research Group ECOBE. p 18-41.

Stragier F. (2010). Natuurlijke structuren als fysieke en psychologische geluidsbuffer. In: Jacobs S., Staes J., De Meulenaer B., Schneiders A., Vrebos D., Stragier F., Vandevenne F., Simoens I., Van Der Biest K., Lettens S. et al. (editors). Ecosysteemdiensten in Vlaanderen: Een verkennende inventarisatie van ecosysteemdiensten en potentiële ecosysteemwinsten. Anterwerpen: Universiteit Antwerpen - Ecosystem Management Research Group ECOBE. p 205-220.

TEEB. (2008). The economics of ecosystems and biodiversity. An interim report. Welzel+Hardt, Wesseling, Germany.

TEEB. (2010). The Economics of Ecosystems and Biodiversity: Mainstreaming the Economics of Nature: A synthesis of the approach, conclusions and recommendations of TEEB. D5.

TEEB. (2011). The Economics of Ecosystems and Biodiversity in national and international policy making. London: Earthscan.

ten Brink P., Gantioler S., Gundimeda H., Sukhdev P., Tucker G., Weber J.L. (2011). Strengthening indicators and accounting systems for natural capital. In: ten Brink P. (editor). The Economics of Ecosystems and Biodiversity TEEB for National and International Policy Makers. Bonn: TEEB. p 79-128.

Turkelboom F. (2010). Primaire Productie - Landbouw. In: Jacobs S., Staes J., De Meulenaer B., Schneiders A., Vrebos D., Stragier F., Vandevenne F., Simoens I., Van Der Biest K., Lettens S. et al. (editors). Ecosysteemdiensten in Vlaanderen: Een verkennende inventarisatie van ecosysteemdiensten en potentiële ecosysteemwinsten. Antwerpen: Universiteit Antwerpen - Ecosystem Management Research Group ECOBE. p 107-121.

Turkelboom F., Raquez P., Jacobs S., Dendoncker N., Fontaine C., Raes L., Durfrêne M., Stevens M. (2012). A framework for ecosystem services classification in Belgium. FUNDP, INBO, UA-ECOBE, UGent, DEMNA. 11 p.

UNCEEA. (2012). Proposed common international classification of ecosystem services. 7th meeting of the UN Committee of Experts on Environmental-Economic Accounting, Rio de Janeiro, 11-13 June 2012.

UNEP-WCMC. (2011). Developing Ecosystem Service Indicators: Experiences and lessons learned from sub-global assessments and other initiatives. Montreal, Canada. CBD Technical Series No. 58.

UNEP. (2010). Nagoya 2010: Report puts economic value of nature on the global political radar. http://wwwuneporg/DocumentsMultilingual/Defaultasp?DocumentID=649&ArticleID=6791.

Van Daele T., Van Reeth W., Dumortier M., Peymen J. (2010). Biodiversity Indicators 2010. The state of Nature in Flanders (Belgium). Brussel. INBO.M.2010.3.

Van der Aa B. (2010). Primaire Productie - Bosbouw. In: Jacobs S., Staes J., De Meulenaer B., Schneiders A., Vrebos D., Stragier F., Vandevenne F., Simoens I., Van Der Biest K., Lettens S. et al. (editors). Ecosysteemdiensten in Vlaanderen: Een verkennende inventarisatie van ecosysteemdiensten en potentiële ecosysteemwinsten. Antwerpen: Universiteit Antwerpen - Ecosystem Management Research Group ECOBE. p 122-141.

Van Der Biest K., Jacobs S. (2011). Wat biedt de Nete aan ecosysteemdiensten en kunnen we die beheren?

Van der Biest K., Van Ballaer B. (2010). Kraamkamerfunctie. In: Jacobs S., Staes J., De Meulenaer B., Schneiders A., Vrebos D., Stragier F., Vandevenne F., Simoens I., Van Der Biest K., Lettens S. et al. (editors). Ecosysteemdiensten in Vlaanderen: Een verkennende inventarisatie van ecosysteemdiensten en potentiële ecosysteemwinsten. Antwerpen: Universiteit Antwerpen - Ecosystem Management Research Group ECOBE. p 182-192.

Van Dooren W., Manning N., Malinska J., Kraan D.J., Sterck M., Bouckaert G. (2006). Issues in output measurement for 'Government at a Glance'. In: Committee P.G., (editor). Paris: OECD.

van Oudenhoven A.P.E., Petz K., Alkemade R., Hein L., de Groot R.S. (2012). Framework for systematic indicator selection to assess effects of land management on ecosystem services. Ecological Indicators 21(0):110-122.

Van Reeth W., Stevens M., Demolder H., Jacobs S., Schneiders A., Simoens I., Spanhove T., Van Gossum P., Peymen J. (2015). Hoofdstuk 2: Conceptueel Raamwerk. In: Stevens M., Demolder H., Jacobs S., Schneiders A., Van Gossum P., Van Reeth W., Peymen J. (editors). Natuurrapport - Toestand en trend van ecosystemen en ecosysteemdiensten in Vlaanderen Technisch Rapport. Brussel: Instituut voor Natuur- en Bosonderzoek.

Vandevenne F. (2010). Cyclering van nutriënten in het Schelde-estuarium. In: Jacobs S., Staes J., De Meulenaer B., Schneiders A., Vrebos D., Stragier F., Vandevenne F., Simoens I., Van Der Biest K., Lettens S. et al. (editors). Ecosysteemdiensten in Vlaanderen: Een verkennende inventarisatie van ecosysteemdiensten en potentiële ecosysteemwinsten. Antwerpen: Universiteit Antwerpen - Ecosystem Management Research Group ECOBE. p 42-60.

Zhang W., Ricketts T.H., Kremen C., Carney K., Swinton S.M. (2007). Ecosystem services and dis-services to agriculture. Ecological Economics 64:253-260.