

# **Prioritization of Ecosystem Services for Ecosystem Accounting**

## **Issues Paper**

Prepared for the WAVES Project and in the  
context of the December 2011 Expert Meeting on  
Ecosystem Accounting

25 November 2011

First draft, pls. do not quote or circulate

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# 1. Introduction

There is an emerging demand for integrating environmental information in economic accounting systems. Several international initiatives have been initiated to address this demand, including the on-going revision of the System of Environmental-Economic Accounts (SEEA) led by the UN Statistics Division, the World Bank-led WAVES Global Partnership and various regional projects like Europe's "GDP and Beyond".

One of the key challenges to integrating environmental information in economic accounting systems is accounting for ecosystem services, i.e. the benefits supplied by ecosystems to society. The potential to capitalize on the recent advances in the analysis, modeling and valuation of ecosystem services in support of environmental accounting systems has been widely recognized. For instance, Eurostat (2002) already provided a discussion regarding the incorporation of environmental and recreational functions in the forest accounts framework (IEEAF), based on results of several pilot studies. Recent work on ecosystem accounts by the EEA (2007, 2010, 2011) describes potential ways to ground monetary accounting adjustments on a firm physical basis, and several recent studies published in the peer-reviewed literature further discuss the principles of ecosystem accounting (e.g. Boyd and Banzhaf, 2007).

In spite of the recent advances, both with regards to the development of ecosystem accounting frameworks and with regards to analyzing ecosystem services, a number of critical questions remain. The various methodological challenges, and the potential next steps towards ecosystem accounting have been the topic of a series of expert meetings with among others Bank staff, EEA, UNSD, and academia. Key issues have been described in UNSD (2011) and include for example (i) proper inclusion of ecosystem services in the overall structure of accounts; (ii) dealing with biodiversity in SEEA; (iii) aggregation and classification of ecosystem services; (iv) translating the surplus-based valuation approaches that have generally been applied in the environmental economics literature to economic metrics consistent with SNA. A next expert meeting is planned for 5-7 December in London.

In the context of the SEEA Revision Process and the WAVES Project, one of the issues identified to require further clarification is which ecosystem services can most readily be incorporated in accounting systems. The objective of this Issues Paper is therefore to: **provide a preliminary prioritization of ecosystem services with regards to the potential they offer for inclusion in systems for environmental economic accounting.** In particular, this concept note discusses:

- (i) Criteria for the prioritization of ecosystem services in environmental economic accounting;
- (ii) A tentative ranking of potential ecosystem services vis-à-vis these criteria;
- (iii) Next steps to take in order to confirm priority ecosystem services.

This Issues Paper is based on a literature survey as well as a pilot survey sent out to a selected group of environmental economists, ecologists and geographers (see Annex 1). The survey served two purposes: (i) to elicit information on ecosystem prioritization from key experts; and (ii) to test the suitability of the survey to obtain information on prioritization and data availability from a wider audience. The survey was sent to 20 experts, and 9 responses were received (see Annex 5).

This Issues Paper first presents a brief review of the main relevant considerations in prioritizing ecosystem services for accounting purposes, followed by a presentation of potential criteria for prioritization. Subsequently, a tentative prioritization of ecosystem services is presented, followed by an analysis of next steps to take in order to finalize the prioritization process.

**Note that this document is produced as input into the discussion on ecosystem prioritization only, it does explicitly not intend to provide a 'definite' ranking of priority ecosystem services for inclusion in accounting systems, as further elaborated in Section 5.** As mentioned above, the preliminary ranking is based on the views of 9 consulted experts combined with a literature review.

## 2. Key considerations in prioritizing ecosystem services.

In order to define criteria for prioritizing ecosystem services, a number of key characteristics of ecosystem services need to be considered. These include: (i) which categories and types of ecosystem services have been distinguished in the various assessments to date; (ii) how do ecosystem services relate to land use; and (iii) which data are available in terms of the biophysical characteristics and/or values of specific ecosystem services? These aspects are briefly reviewed below.

**Definition of ecosystem service.** Several definitions of the concept of ecosystem service have been formulated. Costanza et al. (1997) referred to: 'Ecosystem goods (e.g. food) and services (e.g. waste assimilation) represent the benefits human populations derive, directly or indirectly, from ecosystem functions'. MA (2003) defines 'Ecosystem services are the benefits people obtain from ecosystems'. TEEB (2010) states 'ecosystem services are the direct and indirect contributions of ecosystems to human well-being', hence replacing *benefit* by *contribution*, recognizing that ecosystem services are often provided by a combination of ecological processes and human interventions in the ecosystem. In CICES (Haines-Young and Potschin, 2010), this reasoning is followed and ecosystem services are defined as 'the contributions that ecosystems make to human well-being'. This Issue Paper will follow the CICES definition, given the specific purpose of CICES to support the SEEA revision process. Ecosystem services are further, in line with the above studies including CICES interpreted as comprising both 'goods' and 'services', and to result from the interaction of ecosystems and human actions.

**Classification of ecosystem services.** The first classification of ecosystem services may well be published (in Dutch) in a report of the Dutch ministry for Housing and Spatial Planning (Van der Maarel and Dauvellier, 1978). This Report distinguished Production, Regulating, Carrier and Information Functions. The same categories were used in the subsequent, updated and more widely disseminated, publication of De Groot (1992). More recently, the Millennium Ecosystem Assessment (MA, 2003, 2005) distinguished Supporting, Provisioning, Regulating and Cultural Services, and the TEEB study (2010) added the category of Habitat services while removing the Supporting Services. The CICES study (Haines-Young and Potschin, 2010) built on these preceding studies, and distinguished the three categories of Provisioning, Regulating and Cultural Services. Supporting services and Habitat Services were no longer included as specific classes in the CICES classification. Based on our current understanding of ecosystem services, the CICES classification of ecosystem service categories is coherent and consistent, and was designed in support of the SEEA revision process, and will therefore be followed in this Issues Paper.

**Types of ecosystem services.** The CICES classification made a comprehensive analysis of themes, classes, groups and types of ecosystem services. A total of 59 different types of ecosystem services were distinguished in CICES, which compares to 22 ecosystem services in TEEB, 18 services in MA (2003) – excluding supporting services, and 17 in Costanza et al. (1997). The substantially larger number in CICES is because some services have been split, e.g. commercial and subsistence cropping are now distinguished, and several new services have been added, such as seed dispersal and solar energy provision. Annex 2 presents the list of ecosystem services as distinguished by TEEB (2010) and in CICES (Haines-Young and Potschin, 2010). Note that the CICES paper is a draft, and may be subject to further modifications, also in the context of the SEEA revision process<sup>1</sup>.

The ecosystem service 'biodiversity / nature conservation', sometimes also called the habitat service, is a difficult issue. One could argue that biodiversity is internal to ecosystems much akin to

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<sup>1</sup> For instance, points of discussion may include (i) if recreation and tourism should not feature more prominently in the classification (as it does in other classifications); (ii) how commercial and subsistence service provision can be distinguished (from an ecosystem perspective, it is often difficult to draw the boundary between commercial and subsistence farming); and (iii) why abiotic services unrelated to ecosystems, such as generating power from solar power plants, are included.

supporting services (as in MA, 2003). However, many people also value species diversity and/or the protection of rare species independent of the role of these species in supplying other ecosystem services (Hein, 2010). CICES recognizes the importance of biodiversity conservation through its contribution to the more tangible aspects of wilderness and naturalness. However, as witnessed by the very different way biodiversity is dealt with in recent assessments (MA, TEEB, CICES), this service is both conceptually and in terms of measurement relatively complex, and it is not further considered in this Issues Paper.

**The relation between ecosystem services and economic production.** Ecosystem services can support economic activity in two main ways, i.e. as final and as intermediate service. *Final ecosystem services* directly provide a benefit to people. Part of these final services are already included in economic output such as the commercial supply of wood, crops etc. Another part is not yet reflected in products accounted for in the SNA and needs to be included as additional output. For instance, breakdown and dispersion of pollutants delivers a benefit in terms of reducing costs for waste treatment and in terms of improving air quality and reducing medical costs (Kunzli et al., 2000). Carbon sequestration is a benefit in terms of mitigating future costs related to climate change and may therefore be termed a final ecosystem service (but see e.g. Boyd and Banzhaf, 2007 for a different interpretation of this service).

*Intermediate ecosystem services* are services that support other economic activities (as in the case of pollination supporting agriculture). They share many characteristics with ancillary activities (e.g. cleaning undertaken within a factory) as understood in the SNA. For instance, their output is not intended for use outside the establishment; the outputs are services and not goods; and their value is small compared to the principal or secondary activity of the enterprise. Ancillary activities could possibly be separately identified to make their contribution to production visible.

Note that accounting for final ecosystem services that are not currently included in standard output increases the total value of goods and services produced in an economy, while distinguishing intermediate services as ancillary production does not increase overall GDP (increase in output is offset by an increase in intermediate consumption) but rather leads to revealing the contribution of these ecosystems to production.

**The relation between ecosystems, land use and ecosystem services.** The UN Convention on Biological Diversity has provided the following definition of an ecosystem: 'A dynamic complex of plant, animal and micro-organism communities and non-living environment interacting as a functional unit' (UN, 1992). Following this concept, ecosystems may lack clearly defined boundaries. However, analysis of ecosystem services, as well as ecosystem modeling requires that the object of the analysis is clearly defined. Therefore, this Issues Paper uses a slightly modified, spatially explicit definition of ecosystems: 'the individuals, species and populations in a spatially defined area, the interactions among them, and those between the organisms and the abiotic environment' (Likens, 1992). Often, in the identification of ecosystems, boundaries between ecosystems are drawn on the basis of relative homogeneousness, in terms of components, processes and structure, and in terms of having strong internal versus external functional relations (Likens, 1992). However, in practice, boundaries between ecosystems may often be gradual and diffuse and the boundary may be difficult to draw based on ecological criteria.

In order to spatially analyze ecosystem services, ecosystem services supply can be linked to land cover. Land cover relates to the observable biotic and abiotic configuration of the landscape. A range of different land cover and biome classifications have been developed<sup>2</sup>. One of the most detailed land cover classification systems is CORINE, developed by the European Environment Agency. CORINE covers 35 countries (the EU-27, Bosnia-Herzegovina, Croatia, Former Yugoslav Republic of Macedonia, Kosovo, Liechtenstein, Norway, Serbia, Turkey). It's land cover product has a resolution of 100 by 100 m, and a minimum unit mapping size of 25 hectares. Three levels of land cover classes are distinguished (the first two levels are presented in Table 1). CORINE has been developed based on a range of different sources, including satellite imagery, thematic maps and aerial photographs. The land cover classification system in CORINE is focused on European

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<sup>2</sup> In this Issue Paper, only a brief summary of land cover aspects relevant for prioritization can be presented, but see for a more detailed analysis of land cover aspects for example (FAO, 2011).

land cover types, for instance deserts are classified as a subcategory under 'Forests and semi-natural areas' whereas outside of Europe many deserts are natural systems. The distinction of different forest types in CORINE is at Level 3 (not shown in Table 1).

There are also a range of products that provide global coverage of land cover. Three examples of global land cover maps are (i) the UMD (University of Maryland) global land cover map; (ii) GLC2000; and (iii) GlobCover. The UMD has a resolution of 1 km<sup>2</sup> and is based on AVHRR satellite data acquired between 1981 and 1994. The JRC GLC2000 is based on images of 2000 and has a resolution of 1 km. The GlobCover project is a collaboration between ESA, FAO, UNEP, JRC, IGBP and GOCF-GOLD and resulted in a global land-cover map for the year 2005, using as main source of data the fine resolution (300 m) mode data from the ENVISAT satellite<sup>3</sup>. The GLC2000 and GlobCover maps have been validated and their classification accuracy is known.

Land cover maps allow spatial analysis of ecosystem services supply. There are, however, differences in the classes distinguished in land cover maps, and the classes distinguished in ecosystem service valuation studies, as categorized by for instance the TEEB project. In addition, there are several different land cover classification systems (GLC2000 and GLOBCOVER include the same land cover classes, see Annex 3). To illustrate these differences, Table 1 compares the European CORINE land cover and global UMD land cover units with the TEEB biome classification. Table 1 illustrates that land cover and ecosystem classifications are based on different parameters, but that there is often an important overlap between them. Note that TEEB also has a 2<sup>nd</sup> classification level (ecosystem level), where for instance different types of forests are distinguished<sup>4</sup>.

Table 1. Examples of land cover and ecosystem classifications. Note that classes between different classification systems do not entirely correspond.

CORINE Level 1	CORINE Level 2	UMD	TEEB Level 1.
1. Artificial surfaces	Urban fabric	Urban and Built	Urban
	Industrial, commercial and transport units		
	Mine, dump and construction sites		
	Artificial non-agricultural vegetated areas		
2. Agricultural areas	Arable land	Cropland	Cultivated
	Permanent crops		
	Pastures	Grassland	Grassland and rangeland
	Heterogeneous agricultural areas	Wooded Grassland	
3. Forest and semi-natural areas	Forests	Evergreen Needleleaf Forest	Forests
		Evergreen Broadleaf Forest	
		Deciduous Needleleaf Forest	
		Deciduous Broadleaf Forest	
		Mixed Forest	
		Woodland	Woodland and shrubland
		Shrub and/or herbaceous vegetation association	Closed Shrubland
	Open spaces with little or no vegetation	Open Shrubland	Tundra
4. Wetlands	Inland wetlands	Bare Ground	Desert
			Ice/Rock/Polar
	Marine wetlands		Wetlands
5. Water bodies	Inland water		Rivers & Lakes
	Marine		Coastal Systems
			Marine/Open oceans

Linking ecosystem services to land cover first requires identifying a potentially suitable land cover classification system. In addition to the categories identified in land cover maps, there may be a need to add the categories of Ocean and Atmosphere. Ocean is required to account for fishing and

<sup>3</sup> See for more information: <http://www.gocf-gold.uni-jena.de/sites/globcover.php>

<sup>4</sup> For example, in the case of forests: (i) tropical rain forest; (ii) tropical dry forest; (iii) temperate rain/evergreen; (iv) temperate deciduous; and (v) boreal/coniferous forest.

fish harvests, 'Atmosphere' needs to be added, in line with other environmental accounting systems, since the atmosphere presents a place where emissions can be disposed of and broken down. Annex 4 presents an illustration of how land cover classes can potentially be linked to ecosystem services supply.

**Published studies on ecosystem services supply.** The TEEB (2010) study provides an overview of the state-of-the art in ecosystem services analysis and valuation. For the TEEB study, several hundred publications on ecosystem services were screened, and 160 of these were selected (on basis of a number of criteria including quality of the study) and inserted in a database. Many of these studies provided value estimates for more than one service, and a total of 527 value estimates for specific services were found. Each value point was subsequently linked to a specific biome or ecosystem following the classification presented in Table 1, right hand column. Values were expressed in standardized per hectare values in 2007 International dollars. The value conversions were based on GDP deflators and PPP converters from the World Bank Development Indicators. Figure 1 presents an overview of the value estimates retrieved in the TEEB project in order to provide an idea of data availability on ecosystem services values.

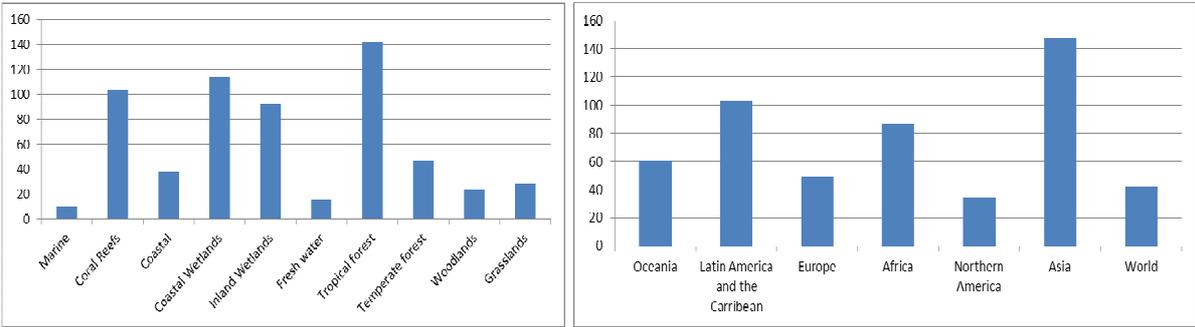


Figure 1. Number of value estimates by biome and by continent (source: TEEB, 2010)

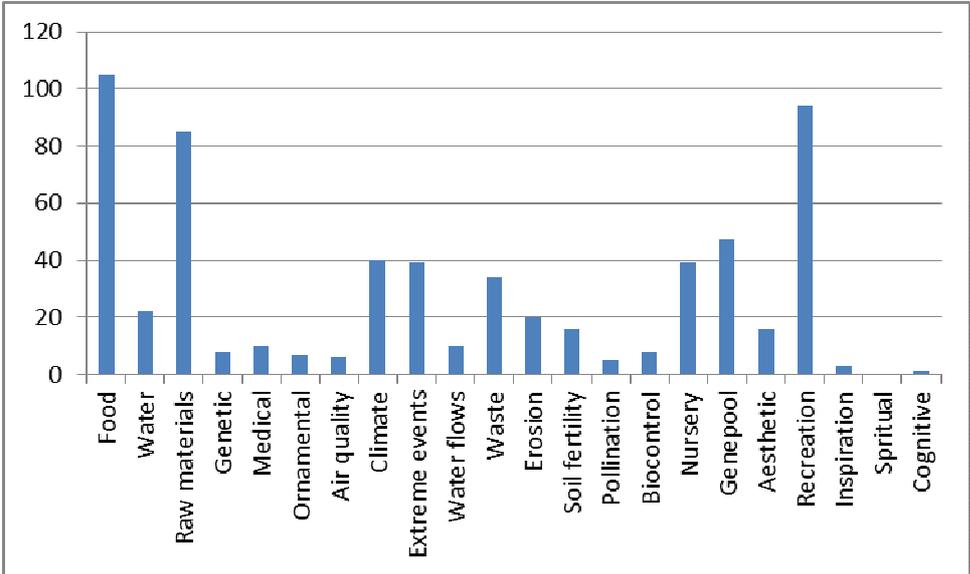


Figure 2. Number of value estimates by ecosystem service (source: TEEB, 2010).

For Desert and Polar regions there were a low number of value data points and these were excluded from the TEEB analysis, as were cultivated land and urban areas in TEEB because they are human-dominated systems. In the development of ecosystem accounting methods, it may need to be considered how these land cover categories can be included, in spite of the lack of data.

### 3. Criteria for prioritizing ecosystem services in ecosystem accounting

Based on the response to the Survey, a list of criteria for prioritizing ecosystem services is presented in Table 2 below. These criteria are based on the tentative list of criteria presented in Annex 1, but the criteria themselves have been reformulated based on the feedback from the respondents. Note that each criterion may not be equally important, however the respondents were not uniform in endorsing or rejecting specific criteria so no ranking of importance of these various criteria can be given. In particular the criterion ‘possibility to influence environmental and/or economic decision making’ was evaluated differently by the respondents, with some arguing that this should be a prime driver for selecting ecosystem services and other respondents indicating that the impact on decision making will be through the overall SEEA and therefore this should not be a criterion for prioritization.

A key aspect, identified by most respondents, was the issue of scaling up local, point based estimates of ecosystem services supply to national level aggregates. This process requires both a high availability of point-based data on ecosystem services supply, credible methodologies for spatial modeling and/or interpolation at higher scales, and spatial data to allow spatial modeling or interpolation at aggregated scales. This key issues is reflected in each of the first four criteria (numbers 1 to 4) of Table 2.

Table 2. Criteria for prioritization of ecosystem services for accounting purposes.

	Criterion	Brief explanation
Data availability and modeling		
1	Availability of broadly accepted methods for analyzing ecosystem services supply in physical terms at a high aggregation level	Priority may initially be given to services for which broadly accepted modeling / quantification techniques are available.
2	Availability of broadly accepted methods for analyzing ecosystem services supply in economic terms at a high aggregation level	Priority may initially be given to services for which broadly accepted valuation approaches are available.
3	Availability of data for measuring ecosystem services in physical terms	Producing national level accounts will often require scaling up parcel level estimates of ecosystem services to a national level based on underlying spatial data. Both point-based data and spatially explicit data (e.g. on land cover, soils, water levels, ecosystem productivity, etc.) may be required to analyze a service at national level.
4	Availability of data for measuring ecosystem services in economic terms	
5	Possibility to generate new data on ecosystem services supply	
Other criteria		
6	Economic importance of the ecosystem service.	Priority may be given to those services that generate substantial economic benefits.
7	Possibility to influence environmental and/or economic policy and decision making (decision making context)	Priority may be given to services that can relatively easily be influenced by decision making in order to have maximum relevance for policy making.
8	Sensitivity of the service to changes in the environment, including from anthropogenic stressors.	Priority may be given to services that are sensitive to environmental change and/or under particular threat from human activities in order to enhance the interest of policy makers.
9	Whether the service is a final or intermediate ecosystem service	Final ecosystem services may be prioritized

## 4. Tentative ranking of ecosystem services

Analysis of the responses to the Survey resulted in a first scoring of the feasibility (considering data availability and the availability of credible modeling approaches) of producing ecosystem accounts. Because data availability and methods for analyzing specific services may differ strongly between ecosystem types, the feasibility of analyzing ecosystem services was analyzed for specific ecosystem types. In line with the scope of the study, only regulating and cultural services were included.

Table 3 and Table 4 below provide an indication of the average response obtained for each service and ecosystem combination. Seven respondents filled in this part of the Survey. The scores given in Tables 3 and 4 represent the average response, with equal weighting to each of the responses. The scoring method of Tables 3 and 4 differs slightly from that of the Survey. The Survey (see Annex 1) asked respondents to score ecosystem services on a scale of '--' (not suitable at all) to '++' (very suitable). However, based on the feedback obtained, to facilitate interpretation of the results, Tables 3 and 4 are ranked from '0' (not suitable at all); '+' (low suitability); '++' (suitable) to '+++' (very suitable). A value of 0 may also mean that the service is not applicable for a particular ecosystem type.

Table 3 presents the perceived feasibility with regards to *biophysical* quantification of ecosystem services supply at national scales, and Table 4 presents the same with regards to quantification in *economic* terms. In general, there is consistency between the two tables, which may partly stem from the notion that economic quantification is only possible if biophysical quantification is feasible as well. Therefore, for a number of ecosystem services, the scores in Table 4 are lower than those in Table 3.

For many services, there was consistency between the respondents on the feasibility of analyzing specific ecosystem services for accounting purposes in relative terms. For instance, carbon sequestration was perceived to be more feasible than pollination by all respondents, even though the specific scores provided differed between the respondents. Services with less consistency between respondents were, in particular, 'control of erosion and sedimentation', and 'inspiration, spiritual and cognitive benefits'. In addition, most respondents indicated to not be very familiar with data availability for Tundra ecosystems.

Table 3. Perceived feasibility of quantifying ecosystem services in different biomes in **biophysical** terms.

Regulating Service	Feasibility (from 0 to +++)							
	Coastal	Wetlands	Lakes and rivers	Forests	Woodland and shrubland	Grass and rangeland	Tundra	Cultivated areas
Regulation of air quality through filtration of air pollutants including particulate matter	0	0	0	++	+	+	0	+
Carbon sequestration	0	+	0	+++	+++	++	++	++
Regulation of hydrological flows through buffer function of (forest) ecosystems	0	+	+	++	++	+	+	+
Protection of coastal zones from floods by coastal ecosystems, for instance mangroves	+	+	0	++	+	0	0	0
Control of erosion and sedimentation	+	+	0	++	+	+	0	++
Maintenance of soil fertility	0	0	0	+	+	+	0	++
Pollination	0	0	0	+	+	+	0	++
Control of pests and diseases	0	0	0	+	0	0	0	+
Nursery service: regulation of species populations	+	+	+	+	+	+	0	0
<i>Cultural services</i>								
Recreation and tourism	+++	++	+++	+++	++	++	+	+
Inspiration, spiritual, cognitive	+	0	+	+	0	0	0	0
Amenity service (providing an attractive living environment)	+	+	++	++	+	+	0	0

Table 4. Perceived feasibility of quantifying ecosystem services in different biomes in economic terms.

<i>Regulating Service</i>	Feasibility (from 0 to +++)							
	Coastal	Wetlands	Lakes and rivers	Forests	Woodland and shrubland	Grass and rangeland	Tundra	Cultivated areas
Regulation of air quality through filtration of air pollutants including particulate matter	0	0	0	+	+	0	0	0
Carbon sequestration	0	+	0	+++	+++	++	+	++
Regulation of hydrological flows through buffer function of (forest) ecosystems	0	0	+	++	++	+	+	+
Protection of coastal zones from floods by coastal ecosystems, for instance mangroves	+	+	0	++	+	0	0	0
Control of erosion and sedimentation	+	+	+	+	++	+	0	+
Maintenance of soil fertility	0	0	0	+	+	0	0	++
Pollination	0	0	0	+	+	0	0	+
Control of pests and diseases	0	0	0	0	0	0	0	+
Nursery service: regulation of species populations	+	+	+	+	+	+	0	0
<i>Cultural services</i>								
Recreation and tourism	++	++	++	++	++	++	+	+
Inspiration, spiritual, cognitive	0	0	0	0	0	0	0	0
Amenity service (providing an attractive living environment)	++	+	++	+	+	+	+	+

Based on the results of the literature review and the outcomes of the Survey among ecosystem services experts, as expressed in Tables 2 to 4, a preliminary prioritization of ecosystem services with regards to potential suitability for inclusion in ecosystem accounts has been conducted. The results are presented in Table 5. Note that given the limited number of respondents to the Survey (9) the scoring of Table 5 is preliminary, and meant as basis for discussion only. Scores are expressed in the range of 0 (potentially low priority) to +++ (potentially high priority).

Note also that Tables 3 and 4 reflect the scores provided by a small group of experts from different parts of the globe (Annex 5). However, there may be significant differences between individual countries in terms of data availability and therefore feasibility and potentially the priority with regards to inclusion in ecosystem accounts. This aspect could however not be further examined with the time available for this Issues Paper.

Table 5. Preliminary scoring of ecosystem services with regards to their potential priority for ecosystem accounting (from 0 to +++)

Service	Availability of biophysical methods	Availability of economic methods	Availability of biophysical data	Availability of economic data	Options for generating new data	Economic importance	Possibility to influence decision making	Sensitivity to change in the environment	Final service ?	Score	Comments
Regulation of air quality through filtration of air pollutants including particulate matter	++	++	+	+	+	+++	++	++	Yes	++	There is still uncertainty and limited data regarding the capture of air pollution (often expressed as particulate matter concentration or PM) by vegetation. In addition, there are remaining challenges related to linking PM deposition to air quality, and to quantifying health and economic impacts.
Carbon sequestration	+++	+++	+++	++	++	+++	+++	+++	?	+++	This appears to be the most feasible service for inclusion in SEEA. Data are available and there is broad consensus on the methods to apply to quantify this service. There is no consistency in the literature, however, if this is a final or an intermediary service.
Regulation of hydrological flows through buffer function of (forest) ecosystems	+	+	+	+	++	++	++	+++	?	+	This service has been much studied, but almost exclusively on a watershed scale. Analyzing the service is data intensive, and scaling up is very difficult since no watershed is alike. This service may therefore have low potential at this stage.
Protection of coastal zones from floods by coastal ecosystems, for instance mangroves	+++	++	++	+	++	++	++	+++	Yes	++	The impact of dunes, coral reefs and mangroves in terms of flood protection in coastal zones has been widely studied in the ecological economic literature. Scaling up seems in principle feasible, provided that the value of this service is modeled at a higher scale while correcting for population density, local topography, etc.
Control of erosion and sedimentation	++	+	+	+	+	+	++	++	No	+	Control of erosion and sedimentation has been frequently studied, in particular in soil sciences. Economic impacts are not always easy to establish, there are different valuation methods that often lead to different outcomes. Scaling up is difficult, detailed spatial run-off and erosion models are needed to establish the costs (and benefits) of erosion and sedimentation.
Maintenance of soil fertility	+++	+	++	+	++	++	?	++	No	+	Soil fertility is critical to agricultural production, but impacts of ecosystem change and management are difficult to disentangle.

Pollination	++	++	+	+++	+	++	?	+	No	+	Pollination is well studied in agronomy, but the contribution of ecosystems (e.g. natural patches in the landscape) to maintaining natural pollinators is determined at a very local scale, and therefore difficult to scale up and analyze at aggregated scales
Control of pests and diseases	+	+	+	+	+	+	?	+	No	0	This service also depends on ecosystem configuration and processes at a very local scale and scaling up is very difficult. In addition, data are lacking and the contribution of the ecosystem versus the impact of management is difficult to disentangle.
Nursery service: regulation of species populations	+	+	+	+	+	++	?	++	No	0	Data are relatively scarce for this service, and scaling up may be difficult given the large variations between the nursery service of different ecosystems in terms of species involved, local population sizes, interannual variability in populations, etc.
<i>Cultural services</i>											
Recreation and tourism	++	+++	+	+++	+	+++	+	+	Yes	+++	There are relatively ample data for this service, in terms of visitor numbers and value added generated in the tourism sector. A challenge is disentangling the contributions of recreation facilities (cycling paths, hotels, restaurants) from ecosystem contributions (scenery, nature, etc.)
Inspiration, spiritual, cognitive	+	0	0	0	+	?	?	?	Yes	0	There is considerable uncertainty on how this service can be quantified and measured.
Amenity service (providing an attractive living environment)	++	++	+	+++	+	+	+	++	Yes	++	This service can be related to property prices for which broadly accepted methods and in many countries relatively ample data are available.

## 5. Conclusions and potential next steps

### Priority ecosystem services

This first survey (n=9) among experts in the field of ecosystem services showed that, in addition to the provisioning services, the **carbon sequestration service** is believed to be of highest priority for inclusion in an ecosystem accounting system at this point in time. The respondents to the Survey were consistent in indicating this service as priority. A particular aspect with this service is that both storage and sequestering carbon provide an ecosystem service, and that these two aspects are not aligned. A high stock may mean that sequestration is limited because the vegetation is close to its maximum biomass under the ecological conditions pertaining in the particular area. A low stock may mean that there is scope for additional sequestration (e.g. in a recently cut forest with intact soil fertility), but this doesn't have to be the case (e.g. in a desert). In general, it is recommended to consider both underlying stocks and flows of service in developing ecosystem accounts (see also EEA, 2011), and this seems particularly critical for the carbon capture service. It should be noted however, that although scientific methods and data are relatively well developed for this service, this does not equally apply to all ecosystems, with relatively much data available for forests, and relatively few data for lakes and coastal systems. It needs to be decided if a first attempt at establishing ecosystem accounts may need to focus on terrestrial systems excluding lakes and rivers<sup>5</sup>. As one respondent indicated, there may also be data and/or methodological constraints related to analyzing carbon sequestration in degraded forests and in forest/landscape mosaics, which requires further consideration in developing ecosystem accounts.

**Tourism and recreation** is also believed to be a potential priority service. There are relatively ample data and there is a lot of experience with valuing this service. However, most valuation studies in the ecological economics literature have analyzed consumer surplus (often with the travel costs method) for visitors sometimes in combination with benefits for suppliers of recreational services. There is therefore a need to bring value estimates in line with the economic metrics required for SEEA. A question is if and if so how the benefits to recreationists of being able to access ecosystem sites can be included in SEEA or if only benefits to providers of recreational services can be included in SEEA. In addition, contrary to carbon sequestration, it is unclear for the recreation and tourism service to what extent a spatially explicit, bottom-up approach is required. Tourism and recreation statistics are usually maintained for administrative units (commune, country) only, hence not for ecosystem types. It is therefore difficult to analyze the ecological contribution to this service; tourism and recreation will generally depend on a mix of ecosystem related (e.g. scenery, biodiversity) and other (infrastructure, presence of hotels, safety, etc.) factors.

The services believed to be considered a 2<sup>nd</sup> order priority are coastal protection, the amenity service and air filtration. **Coastal protection** may have a high potential for inclusion in ecosystem accounting. A range of valuation studies have analyzed how flood risks decrease as a function of mangrove cover, or the presence of dunes and coral reefs. Technically, extrapolation of the physical aspect of this service is possible, with spatial modeling factors such as population density and topography of the coastal zone to be taken into account. In terms of economic indicators, a starting point for discussion is perhaps to relate this service to the costs of alternative means of coastal protection. Note that more literature is available on coastal protection compared to the flood protection service of riverine ecosystems, such as gallery forests (TEEB, 2010). Hence, ecosystem accounting initiatives may initially focus on coastal protection only.

The **amenity service**, for the purpose of the survey described as providing an attractive living environment, involves a range of different aspects (scenery, local recreational opportunities, clean

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<sup>5</sup> Note that in lakes and rivers, sequestration is mainly based on deposition of carbon in sediments and therefore linked to a combination of (changes in) land use, erosion and run-off patterns, hydrological processes and water management. The link between land cover and service provision is present but less direct compared to the link between land cover and carbon sequestration in terrestrial systems.

air, cultural heritage) - see TEEB, 2010 and the UK NEA, 2011 for a more comprehensive treatment of amenity services and values. In order to avoid double counting, it is important to define this service, or aspects thereof to be included in a SEEA, in a consistent and narrow manner. Respondents of the survey indicated that this service may have potential for inclusion in SEEA based on data availability and current experiences with analyzing this service in both bio-physical and economic terms. This is further illustrated by the UK NEA, that includes the category of non-market urban greenspace. In the UK NEA, the amenity value is related to the presence of protected areas (National Parks, National Trust land and metropolitan green belt), local environmental settings (domestic gardens, local green spaces, rivers) and several habitats (such as woodland, farmland and freshwater). The amenity service is reflected in property prices, and can be revealed through hedonic pricing methods.

**Air filtration** depends on air pollution having a health impact on people, and the presence of ecosystems that capture air pollution. A range of studies have shown that forests remove air pollution by means of dry deposition of pollutants to plant surfaces (Beckett et al. 2000, Nowak et al. 2006). The removal of particles from ambient air generates an economic benefit, related to increased well-being and reduced sickness due to air pollution, however there is still considerable uncertainty on the magnitude of these health impacts (Kunzli et al. 2000). A significant cause of uncertainty, which is also highly relevant in the context of ecosystem accounting, pertains to the distance at which forests influence air quality. For example, a UK study (Willis et al. 2003) assumed that health benefits from air filtration by forests only occur at short distances (<1 km) from the forest. European Commission (2005), however, states that damage assessments of particulate matter pollution need to consider that air pollution (PM) can spread over distances of several hundreds of kilometers from an emission source, which means that it may be reasonable to assume that the impacts of large forests on air quality extends over larger distances than only 1 km from the forest edge. Further clarification of this aspect is required before air filtration services can be included in ecosystem accounting. In addition, it needs to be considered that the value of this service as revealed with WTP studies often depends on the income levels of the population exposed to air pollution. In developing global standards, a question is how impacts of varying income levels on the values of ecosystem services in national ecosystem accounts should be dealt with.

Clearly, these priorities are in addition to the inclusion of relevant **provisioning services** in ecosystem accounts. Provisioning were not included in the Survey and this Issues Paper because accounting methods for provisioning services are already well established and (in principle) included in the national accounts. Note, however, that there is one service that has both a provisioning and a regulating character, the **water supply service**. Water can be supplied for drinking, irrigation and industrial production purposes. Three main sources of water are (i) pumping up groundwater, either from deep aquifers or from shallow wells; (ii) extracting surface water from lakes, rivers or man-made reservoirs; and (iii) desalination. The last one is arguably least connected to ecosystem quality: through the desalination process most pollutants can be removed from the water and through an extension of the pipe used for extracting seawater the supply is relatively independent of coastal water quality.

The first two sources, using ground or surface water, however both rely on the storage and supply service of ecosystems. Water pumped up from aquifers or other subsurface groundwater sources is often of much higher quality (i.e. less polluted) than surface water because of the capacity of ecosystems to breakdown or bind pollutants. Water from rivers, lakes or other reservoirs may be purified by ecosystems, in particular if it has passed through a wetland that has the capacity to break down organic pollutants, and absorb inorganic pollutants. Often, headwaters or complete watersheds important for drinking water production are protected and managed as drinking water extraction area. To date, however, there is as yet no generally applied method for accounting for water resources. Interest in such a method among stakeholders is high, given the widespread notion that global water resources are increasingly being depleted, and the interest of water companies to include watersheds they are managing or owning for drinking water production purposes in their asset books at a value reflecting their actual benefits provided. In addition, there is a relatively large availability of data on water production and water resources, for instance as gathered by drinking water production companies. Hence, although due to its dual nature not covered in this survey on regulating and cultural services, the water provisioning service including the regulating parts of this service could be considered as priority service for ecosystem accounting.

Based on additional recommendations provided by the respondents to the Survey, in combination with the literature review, a number of general recommendations can be formulated as an input into the overall discussion on developing ecosystem accounting methods:

- With regards to physical indicators, there is a need to distinguish stock and flow indicators, as in the amount of fish stock and the annual harvest of fish stock. A specific case is related to carbon, because both the storage and the sequestration of carbon may represent distinct ecosystem services.
- For most services, only point based value estimates are available, and aggregation is required in order to establish national level indicators. Aggregation is a critically important element of ecosystem accounting, but methods for aggregation are not yet readily available and need to be further developed. These methods need to combine (i) point based supply or value estimates; (ii) national statistics on indicators relevant to ecosystem services supply (e.g. tourist entries); and (iii) spatial information and modeling in order to account for the spatial diversity of ecosystems and ecosystem services demand. Because information from ecosystem service valuation studies needs to be combined with spatial data, the number of value estimates per service (Figure 2) does not present the full picture regarding data availability. For each ecosystem service, a different approach to aggregation may be required. Many provisioning and regulating services need to be mapped in order to obtain value estimates at higher aggregation levels, but other services, such as tourism and recreation, may not necessarily require detailed mapping involving linking specific ecosystem units to service supply.
- Different methods for analyzing ecosystem services at higher scales are available (e.g. spatial modeling, spatial regression analysis, geo-statistical interpolation), and the suitability of these methods may well depend on data availability as well as characteristics of the landscape (large continuous ecosystems versus mosaic landscapes).
- In terms of economic analysis, a critical aspect is that many valuation studies have studied the surpluses generated by ecosystem services, whereas accounting requires recording of production based indicators. Aggregation and scaling up surplus indicators is methodologically very complex, however aggregation of production based indicators is consistent with the overall system of national accounting and possibly more straightforward. Nevertheless, this observation implies that there is a need to translate the ecosystem service value estimates as published in the environmental and ecological economics literature from an indication of surplus to an indication of market based production.

## Next steps

In terms of priority (regulating and cultural) ecosystem services, a first set of potential priorities includes: (i) carbon regulation; (ii) recreation and tourism; (iii) coastal protection; (iv) water supply and purification; (v) amenity service; and (vi) air filtration. The survey suggests that this order, which is based on a literature survey of valuation studies and a survey among experts in the field, reflects potential feasibility and importance of including the service. However, it needs to be kept in mind that the number of respondents was relatively small (n=9) and this potential order is meant as input in further discussions on ranking ecosystem services only. Moreover, it is likely that the potential to include these services varies between countries, given differences in data availability and policy priorities between countries.

Hence, in addition to discussing if these services can be included in the WAVES pilot countries, it could be considered obtaining the view of a wider audience on priority ecosystem services, for instance in the context of the December 2011 SEEA expert group meeting or by means of a larger survey. The feedback of respondents and responses obtained result in a number of points that can be improved in such a survey for a wider audience. For instance, as one respondent indicated, there is a need to elicit and indicate if the respondent should answer based on his/her own view or on the basis of an assumed broader view among experts, and to better define suitability in the tables of the questionnaire.

An essential step in developing methods for ecosystem accounting is, clearly, conducting pilot studies focusing on specific countries and/or specific ecosystem services, as currently undertaken in the context of the WAVES project. Lessons from ongoing projects need to be considered in this

processes, such as from the Spanish RECAMAN<sup>6</sup> Project focusing on developing spatially explicit green accounting values for Andalusia and from the ERC funded Ecospace project developing bio-physical ecosystem service accounts on the sub-national scale in the Netherlands, Norway and Indonesia. The outcomes of this Issues Paper provide a first guidance on the potential services that may be considered for further studies including the pilot studies of the WAVES project.

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<sup>6</sup> Renta y Capital de los Montes de Andalucía

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# **Annex 1. Survey. Prioritization of Ecosystem Services for Ecosystem Accounting**

## **SURVEY**

### **Prioritization of Ecosystem Services for Ecosystem Accounting**

Lars Hein and Glenn-Marie Lange, Version 4, 20 October 2011

#### **1. Purpose of the Survey**

This survey is the first step of a 2-stage process that aims to get the view of key experts in the fields of i) biophysical/spatial modelling and ii) economic valuation of ecosystem services about the state of the science for measuring and valuing ecosystem services.

This information will be used to prioritise work on developing accounts for ecosystem services for the System for Environmental Economic Accounting (SEEA <http://unstats.un.org/unsd/envaccounting/default.asp> ). The SEEA is the framework for integrating information about the environment with national accounts – the most widely used source of information about the economy, including indicators such as GDP as well as detailed statistics for analysis such as input-output tables. The survey will feed directly into both the World Bank coordinated WAVES Programme<sup>7</sup> and the SEEA revision process coordinated by UN Statistics Division.

The 1<sup>st</sup> stage survey will be distributed among a small group of experts who are somewhat familiar with the SEEA in order to get initial results and to refine the survey instrument. The 2<sup>nd</sup> stage survey based on a refined questionnaire will be distributed to a broader group of experts, as part of the international consultation process on the SEEA.

The outcome of this first survey will be used in support of an Issues Paper on the Prioritisation of Ecosystem Services to be presented for discussion at the UNSD/World Bank/EEA SEEA expert meeting on 5 to 7 December 2011. This Issues Paper will support discussions on the appropriate next steps towards better accounting for ecosystem services in the SEEA and, hence, in economic statistics and analysis.

The survey aims to obtain information on two specific questions:

1. Which are the relevant criteria for prioritizing ecosystem services in accounting systems?
2. For which ecosystem services are the measurement and valuation currently robust enough so that reasonable estimates of value can be incorporated in national accounting systems?

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<sup>7</sup> Wealth Accounting and Valuation of Ecosystem Services (WAVES)—a 5-year program to promote environmental accounting and extend the accounts for ecosystems and their services, [www.worldbank.org/programs/waves](http://www.worldbank.org/programs/waves)

- The 1<sup>st</sup> stage survey will provide a *preliminary assessment* of priorities and identify where the survey needs to be more detailed
- the 2<sup>nd</sup> stage survey, with more detailed questions, will systematically identify the particular obstacles to measurement and valuation.

To give a brief example:

Storage of carbon in forests would be a priority ecosystem service because

- methodology for measurement of the volume of carbon stored is largely agreed,
- methodology can be implemented on a large scale, across biomes using a small number of parameters for which data are relatively easily obtained,
- measuring carbon is a policy priority, and
- there is broad agreement about how to value carbon storage

For other services, scaling up from local/parcel measurements to landscape/regional or national levels may be problematic because of the site-specific nature of the provision of ecosystem service and/or its value.

The Survey focuses on Regulating and Cultural Services since accounting methods for Provisioning Services are already well established and included in the national accounts (in principle, if not always well measured).

Regulating services are valuable as inputs to the production of goods and services that directly benefit people (largely the provisioning services and recreation), but are not *explicitly* represented in the national accounts, for instance because they have no market prices. Such services can be termed *Intermediate ecosystem services* in the framework of national accounts. Hence, *Intermediate ecosystem services* are services that support other economic activities (as in the case of pollination supporting agriculture). They share many characteristics with ancillary activities (e.g. cleaning undertaken within a factory) as understood in the System of National Accounting.

Filling in the Survey should not take more than 10 to 15 minutes. We recognize that you may not be so familiar with all ecosystem services, or services across all biomes, and do not expect you to attempt to provide an opinion about those with which you are not familiar.

Participants in the Survey will be acknowledged in the Issues Paper and will receive a copy of the paper when finalised.

**2. Criteria for prioritizing ecosystem services’ inclusion in SEEA**

In order to facilitate the selection of ecosystem services that should be prioritised in developing ecosystem accounting methods at a national scale, your view is asked on the **criteria** that should be used to identify these priority ecosystem services. The table below presents a first proposal for these criteria, pls. modify where required, and pls. add additional criteria where relevant.

Table 1. Potential criteria for selecting priority ecosystem services to be included in SEEA.

Criterion (proposal)	Your modification / view / comments:
<i>Opportunities and constraints related to modelling and data</i>	
1 Degree of understanding of the ecological processes underlying the service.	
2 Degree of understanding of the impacts on production and consumption generated by the service.	
3 Availability of data for measuring ecosystem services	
4 Potential to scale up parcel ecosystem estimates to landscape/national level value estimates. E.g., the ability to reliably describe the provision of services in terms of a small number of parameters for which data are readily available	
<i>Opportunities and constraints related to economic valuation; economic significance and impacts</i>	
5 Availability of economic data for valuing ecosystem services	
6 Potential to scale up local value estimates to national level value estimates.	
7 Economic importance of the ecosystem service.	
8 Possibility to influence environmental and/or economic policy and decision making	
<b>YOUR ADDITIONAL CRITERIA:</b>	(plus elaboration if required:)

**3. Identification of ecosystem services that can most readily be incorporated in accounting systems**

Table 2 and 3 present the regulating and cultural services as distinguished in the TEEB study. Table 2 focuses on biophysical aspects, Table 3 on economic aspects. Pls. indicate

your judgement of the feasibility of accounting for ecosystem services at the national scale, using the criteria stated in Table 1 in combination with your own criteria.

Table 2 distinguishes between the different biome types (based on the TEEB classification) in order to elicit if in the selection of priorities for ecosystem accounting it is also required to consider priority biome types, or combinations of biomes and ecosystem services<sup>8</sup>.

Pls. use a ranking system including:

- - not suitable at all
- not suitable
- 0 may be suitable / no opinion
- + suitable
- ++ very suitable

Pls. indicate explanatory comments in the column on the right.

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<sup>8</sup> A number of small modifications of the TEEB classification have been introduced in order to ensure the consistency of Tables 2 and 3. In particular, the biomes Marine, Urban, Ice/rock/polar and Desert have not been included because the supply of most of the ecosystem services listed in Tables 2 and 3 is very small compared to the supply in other biomes. In addition, the description of the ecosystem services in Tables 2 and 3 has in some cases been narrowed down to comprise only the most significant type of benefit provided by the service, based on a review of the TEEB valuation database. E.g. Tables 2 and 3 only elicit information on the flood protection service of coastal ecosystems (where most data are available) and not for the flood protection service of riparian ecosystems (on which very few studies have been conducted).

Table 2. Pls. indicate your judgement of the feasibility of national level assessments of ecosystem services supply in support of ecosystem accounting – **biophysical quantification**

*In your opinion, what is the feasibility of constructing national level, **biophysical** indicators reflecting the supply of each ecosystem service in Table 2 (given data limitations, methodological uncertainties, etc.) ? Pls answer for specific biomes.*

<i>Regulating Service</i>	Feasibility (from -- to ++)								Pls identify main barrier(s)
	Coastal	Wetlands	Lakes and rivers	Forests	Woodland and shrubland	Grass and rangeland	Tundra	Cultivated areas	
Regulation of air quality through filtration of air pollutants including particulate matter									
Carbon sequestration									
Regulation of hydrological flows through buffer function of (forest) ecosystems									
Protection of coastal zones from floods by coastal ecosystems, for instance mangroves									
Control of erosion and sedimentation									
Maintenance of soil fertility									
Pollination									
Control of pests and diseases									
Nursery service: regulation of species populations									
Others: ....									
<i>Cultural services</i>									
Recreation and tourism									
Inspiration, spiritual, cognitive									
Amenity service (providing an attractive living environment)									

Table 3. Pls. indicate your judgement of the feasibility of national level assessments of ecosystem services supply in support of ecosystem accounting – **economic valuation**

*In your opinion, what is the feasibility of constructing national level, **economic** indicators reflecting the supply of each ecosystem service in Table 3 (given data limitations, methodological uncertainties, etc.) Please answer for specific biomes.*

<i>Regulating Service</i>	Feasibility (from -- to ++)								Pls identify main barrier(s)
	Coastal	Wetlands	Lakes and rivers	Forests	Woodland and shrubland	Grass and rangeland	Tundra	Cultivated areas	
Regulation of air quality through filtration of air pollutants including particulate matter									
Carbon sequestration									
Regulation of hydrological flows through buffer function of (forest) ecosystems									
Protection of coastal zones from floods by coastal ecosystems, for instance mangroves									
Control of erosion and sedimentation									
Maintenance of soil fertility									
Pollination									
Control of pests and diseases									
Nursery service: regulation of species populations									
Others: ....									
<i>Cultural services</i>									
Recreation and tourism									
Inspiration, spiritual, cognitive									
Amenity service (providing an attractive living environment)									

#### **4. Any other comments or insights**

Finally, pls. share with us any other comments you would like to make, or insights you want to share regarding national level accounting for ecosystem services.

In particular, we would be interested in (i) other criteria or insights relevant to the development of an ecosystem accounting system; and (ii) advise on on-going projects that would generate methodological insights or data.

#### **Other comments:**

**Thank you for your input !**

## Annex 2. TEEB and CICES classifications of ecosystem services

Table 2.1 and 2.2 present the ecosystem services distinguished in TEEB and CICES. Given the focus of this Issues Paper on services related to ecosystems, table 2.2 does not include the abiotic services included in CICES.

Table 2.1 Ecosystem service types as distinguished in TEEB and the total number of value estimates per service included in the TEEB database.

Service	# of value estimates
<b>PROVISIONING SERVICES</b>	<b>487</b>
<b>Food</b> (e.g. fish, game, fruit)	201
<b>Water</b> (e.g. for drinking, irrigation, cooling)	51
<b>Raw Materials</b> (e.g. fiber, timber, fuel wood, fodder, fertilizer)	167
<b>Genetic resources</b> (e.g. for crop-improvement and medicinal purposes)	11
<b>Medicinal resources</b> (e.g. biochemical products, models & test-organisms)	38
<b>Ornamental resources</b> (e.g. artisan work, decorative plants, pet animals, fashion)	7
<b>Provisioning values (general)</b>	12
<b>REGULATING SERVICES</b>	<b>320</b>
<b>Air quality</b> (e.g. capturing (fine)dust, chemicals, etc)	8
<b>Climate</b> (incl. C-sequestration, influence of vegetation on rainfall, etc.)	87
<b>Extreme events</b> (eg. storm protection and flood prevention)	62
<b>Water flows</b> (e.g. natural drainage, irrigation and drought prevention)	10
<b>Waste</b> (especially water purification)	65
<b>Erosion prevention</b>	32
<b>Soil fertility</b> (incl. soil formation)	31
<b>Pollination</b>	9
<b>Biological control</b> (e.g. seed dispersal, pest and disease control)	15
<b>Regulating values (general)</b>	1
<b>HABITAT &amp; SUPPORTING SERVICES</b>	<b>120</b>
<b>Life cycles</b> (incl. nursery service)	19
<b>Genetic diversity</b> (especially in gene pool protection)	101
<b>CULTURAL &amp; AMENITY SERVICES</b>	<b>191</b>
<b>Aesthetic</b>	10
<b>Recreation</b>	165
<b>Inspiration</b>	5
<b>Spiritual experience</b>	2
<b>Cognitive development</b>	9
<b>Cultural values (general)</b>	12
<b>Total:</b>	<b>1251</b>

Table 2.2. Ecosystem service types as distinguished in CICES (slightly modified).

Provisioning Services	<ul style="list-style-type: none"> <li>Commercial cropping</li> <li>Subsistence cropping</li> <li>Commercial animal production</li> <li>Subsistence animal production</li> <li>Harvesting wild plants and animals for food</li> <li>Commercial fishing (wild populations)</li> <li>Subsistence fishing</li> <li>Aquaculture</li> <li>Harvesting fresh water plants for food</li> <li>Commercial fishing (wild populations)</li> <li>Subsistence fishing</li> <li>Aquaculture</li> <li>Harvesting marine plants for food</li> <li>Water storage</li> <li>Water purification</li> <li>Non-food plant fibres</li> <li>Non-food animal fibres</li> <li>Ornamental resources</li> <li>Genetic resources</li> <li>Medicinal resources</li> <li>Plant based energy resources</li> <li>Animal based energy resources</li> </ul>
Regulating Services	<ul style="list-style-type: none"> <li>Remediation using plants</li> <li>Remediation using micro-organisms</li> <li>Dilution</li> <li>Filtration</li> <li>Sequestration of nutrients in organic sediments, removal of odours</li> <li>Air flow regulation by windbreaks, shelter belts eg. by process</li> <li>Air flow regulation by ventilation</li> <li>Attenuation of runoff and discharge rates</li> <li>Water storage</li> <li>Sedimentation</li> <li>Attenuation of wave energy</li> <li>Erosion protection</li> <li>Avalanche protection</li> <li>Global climate regulation (incl. C sequestration)</li> <li>Local &amp; Regional climate</li> <li>Water purification and oxygenation</li> <li>Cooling water</li> <li>Maintenance of soil fertility</li> <li>Maintenance of soil structure</li> <li>Pollination</li> <li>Seed dispersal</li> <li>Biological pest and disease control mechanisms</li> <li>Maintaining nursery populations</li> </ul>
Cultural Services	<ul style="list-style-type: none"> <li>Landscape character</li> <li>Cultural landscapes</li> <li>Wilderness, naturalness</li> <li>Sacred places</li> <li>Charismatic wildlife or habitat</li> <li>Prey for hunting or collection</li> <li>Scientific</li> <li>Educational</li> </ul>

### Annex 3. Land cover units in the GlobCover map.

The Table below presents the 22 units distinguished in the global land cover map of GlobCover.

II. Value	GlobCover global legend
11	Post-flooding or irrigated croplands
14	Rainfed croplands
20	Mosaic Cropland (50-70%) / Vegetation (grassland, shrubland, forest) (20-50%)
30	Mosaic Vegetation (grassland, shrubland, forest) (50-70%) / Cropland (20-50%)
40	Closed to open (>15%) broadleaved evergreen and/or semi-deciduous forest (>5m)
50	Closed (>40%) broadleaved deciduous forest (>5m)
60	Open (15-40%) broadleaved deciduous forest (>5m)
70	Closed (>40%) needleleaved evergreen forest (>5m)
90	Open (15-40%) needleleaved deciduous or evergreen forest (>5m)
100	Closed to open (>15%) mixed broadleaved and needleleaved forest (>5m)
110	Mosaic Forest/Shrubland (50-70%) / Grassland (20-50%)
120	Mosaic Grassland (50-70%) / Forest/Shrubland (20-50%)
130	Closed to open (>15%) shrubland (<5m)
140	Closed to open (>15%) grassland
150	Sparse (>15%) vegetation (woody vegetation, shrubs, grassland)
160	Closed (>40%) broadleaved forest regularly flooded - Fresh water
170	Closed (>40%) broadleaved semi-deciduous and/or evergreen forest regularly flooded - Saline water
180	Closed to open (>15%) vegetation (grassland, shrubland, woody vegetation) on regularly flooded or waterlogged soil - Fresh, brackish or saline water
190	Artificial surfaces and associated areas (urban areas >50%)
200	Bare areas
210	Water bodies
220	Permanent snow and ice

Source: GLOBCOVER 2009 Product description and validation report, 18/02/2011, page 19

## Annex 4. Illustration of the relation between land cover and ecosystem services supply.

The land cover units are loosely based on CORINE, the Table is not comprehensive with regards to ecosystem services. The Table presents an illustration to serve as a basis for discussion only .

	Final service						Intermediate services		
	Part of standard output			Include as additional output			Ancillary production		
<i>Land cover</i>	<i>Wood</i>	<i>Crops</i>	<i>Other product</i>	<i>Carbon sequestration</i>	<i>Recreation</i>	<i>Breakdown/ dispersion of pollution</i>	<i>Pollination</i>	<i>Hydrological service</i>	<i>Other regulating services</i>
Urban land									
Agricultural land		X	X	X	X		X		
Forests and semi-natural land	X		X	X	X	X	X	X	
Wetland			X	X	X	X		X	
Inland water bodies			X	X?	X	X		X	
Other terrestrial land (including barren land)			X	X					
Marine			X	X	X				
Atmosphere						X			

## **Annex 5. Respondents to the Survey**

David Barton (NINA, Norway)

Ian Bateman (University of East Anglia, UK)

Jim Boyd (Resources for the Future, USA)

Alejandro Caparros (Instituto de Políticas y Bienes Públicos, Spain)

Neville Crossman (Csiro, Australia)

Peter May (Federal Rural University of Rio de Janeiro, Brazil)

David Simpson (EPA, USA)

Roy Haines-Young (Nottingham University, UK)

Louise Willemen (JRC, Italy)