A synthesis of approaches to assess and value ecosystem services in the EU in the context of TEEB

Final Report

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Disclaimer

The authors bear full responsibility for the content of this report. The conclusions and recommendations presented in this report are those of the authors and do not necessarily reflect the opinion of the European Commission.

Executive Summary

- This report is designed to provide guidance on the available options and choices for conducting ecosystem services valuation and accounting, with the intention to support EU Member States in addressing Target 2, Action 5 of the EU Biodiversity Strategy[1], that is, to map and assess the state of ecosystems and their services in the national territories of EU Member States by 2014, assess the economic value of such services, and promote the integration of these values into accounting and reporting systems at EU and national level by 2020.
- The report takes stock of existing national and international initiatives related to The Economics of Ecosystems and Biodiversity (TEEB), their main objectives and focus, progress, lessons learned, key issues, and future research priorities. Besides screening reports, proceedings from workshops and websites, representatives from 15 European Member States were contacted by telephone. In addition, opinions on progress, lessons learned and future research needs from close to 50 international experts and practitioners were elicited via two web-based surveys.
- One of the main findings is that there does not exist one single, standard “TEEB” method or approach. Most efforts focus on the mapping of ecosystem services. Hardly any initiative has (yet) been able to integrate ecosystem services assessment and mapping into valuation and accounting. There exists a wide variety of approaches in practice at different geographical and temporal scales, which are only partly related to ongoing efforts at European level to harmonize the classification of ecosystem services, their assessment and reporting, such as the work by the Mapping and Assessment of Ecosystems and their Services (MAES) working group or the European Environment Agency's (EEA) Common International Classification of Ecosystem Services (CICES).
- The report outlines a conceptual framework for the assessment of ecosystem services, drawing on the results of the UK National Ecosystem Assessment (UK NEA), the European Environment Agency (EEA) Common International Classification of Ecosystem Services (CICES), the Mapping and Assessment of Ecosystems and their Services (MAES) working group, and the System of Environmental-Economic Accounting (SEEA) Experimental Ecosystem Accounts. In applying the conceptual framework for ecosystem service assessments, there are a number of choices to be made between classifications, methods and approaches. The report outlines these choices and describes the strengths and weaknesses of each alternative option. Recommendations are presented in this way to allow Member States to choose the information and methods that are of highest relevance to them.
- Choices are organised in a multi-level ‘decision tree’. Choice level 1 involves defining what the purpose of the ecosystem services valuation and accounting exercise is; choice level 2 determines which ecosystem services are of highest relevance; choice level 3

[1] http://ec.europa.eu/environment/nature/biodiversity/comm2006/pdf/2020/1_EN_ACT_part1_v7%5B1%5D.pdf

defines the types of value information that are required; and choice level 4 selects the relevant and appropriate valuation methods.

- In order to harmonize efforts between EU Member States, especially to work towards a common reporting format by 2020, the existing frameworks at European level such as the CICES and the MAES framework and the SEEA experimental accounts need further integration and implementation. The step forwards in Europe would be to allow existing frameworks to be tested, monitor outcomes regularly along the way, and refine the existing frameworks based on actual empirical experiences, data and information.
- The CICES classification and the MAES guidance document will be instrumental in providing an appropriate and consistent framework for this at pan-European level, and allow for comparisons between Member States.
- Key to the successful integration of ecosystem services in existing, modified or new accounting or reporting formats is to (1) establish reliable, scientific links between the biophysical provision of ecosystem services and their economic values, and (2) take into consideration the existence of extensively tested guidelines for environmental accounting over the past decades by statistical offices in order to create and maintain a consistent and coherent System of National Accounts (SNA).
- In order to keep the core SNA intact and modifications traceable, a careful, stepwise approach combining biophysical satellite accounts and separating out clearly defined ecosystem services inside the core SNA is advocated based on the outcomes of the monitoring and implementation path outlined above. Existing integrated frameworks such as the National Accounting Matrix including Environmental Accounts developed and applied in statistical offices across different EU Member States in the 1990s could serve as a reference example for this. Full integration of the economic value of stocks of natural capital and flows of ecosystem services, including those already included in the financial exchange value underlying GDP, based on natural capital accounts in the SNA to ‘go beyond GDP’ will require general consensus on appropriate measurement units and valuation approaches and closer collaboration with and between statistical offices.

1. Introduction and main objectives

Building on TEEB recommendations and the Aichi targets, the EU 2020 Biodiversity Strategy adopted on 3 May 2011 foresees that Member States (MS), with the assistance of the Commission, will map and assess the state of ecosystems and their services in their national territory by 2014, assess the economic value of such services, and promote the integration of these values into accounting and reporting systems at EU and national level by 2020 (Action 5 of the Strategy). In order to support Member States with their national initiatives and explore how to build on these initiatives to work towards an ecosystem assessment at EU level, the European Commission is looking for assistance with a specific focus on the relevant economic aspects involved.

The objectives of this study are to (1) synthesize and evaluate recent and on-going initiatives for accounting and reporting biodiversity and ecosystem service values and assess the scope for integrating these initiatives at the EU level; (2) formulate steps for ecosystem service assessment and valuation into a coherent framework that can be applied by Member States for implementing Action 5 of the EU 2020 Biodiversity Strategy; and (3) assess different approaches for up-scaling and combining ecosystem service values into an EU level assessment.

The structure of the report is as follows. Sections 2, 3 and 4 respectively provide reviews of MS national assessments, other relevant (international) initiatives, and green accounting frameworks. Section 5 presents and discusses the results of two surveys of ecosystem service (ES) assessment practitioners and experts. Section 6 outlines the conclusions and recommendations on valuation and national accounting for MS.

2. Review of MS national assessments

2.1. Overview of MS national assessments

This section provides a review of national assessments of ecosystem services by MS. The collection of information on national assessments accessed available project reports, workshop/meeting proceedings, other online information and direct correspondence with officials and researchers in each MS.

The summary presented in Table 1 reveals a wide disparity across MS in terms of the stage of development of national ecosystem service assessments. There are currently a large number of TEEB inspired national assessment in the early stages of development and implementation. A few MS have already completed extensive national assessments that include valuation of ES, the one conducted in the UK being the most comprehensive one, followed by Ireland (biodiversity) and the Czech Republic (grasslands), while most are at (very) early stages of development of national assessments (e.g. Germany, Poland, Austria, Belgium, Netherlands, Norway) and others have no on-going national assessment (e.g. Sweden, Romania, Italy). These initiatives are expected to deliver results over the coming 1-3 years.

2.2. Synthesis and lessons learned

From the set of completed national assessments, several observations can be made. Regarding the coverage of ecosystems they address, there has generally been a focus on terrestrial ecosystems. Marine ecosystem services are relatively less well explored. In terms of the categorisation of ES, a common classification has not been used. Instead, each national assessment has made its own adaptations of existing classifications (e.g. MA and TEEB), and in some MS discussions about the exact definition of ES are still ongoing (e.g. Germany). This includes discussion about the inclusion or exclusion of biodiversity as a separate ES (often included under cultural services). The coverage of ES assessed in each study is generally broad and includes provisioning, regulating, cultural and in some cases supporting services. In all cases, a subset of ES has been assessed and an even smaller subset has been valued.

Regarding valuation methods, most national assessments that include a valuation component have or intend to apply a wide range of methods, including both primary valuation and value transfer. In the latter case both international and local or national studies have been used depending on the availability of the latter in the specific country. The selection of methods for primary valuation has largely been driven by data availability and applicability to the ES that are included in the assessment.

Table 1. Summary of MS national assessments of ecosystem services

Member State	Stage of National Assessment	Name of Initiative	Contact Person	Timeframe	Ecosystems Addressed	ES Categorisation	ES Addressed	Valuation methods
Austria	Early development	TEEB scoping study	Mr. Michael Zika (WWF)	Launched June 2012				Not known yet
Belgium	Early development	TEEB Flanders; TEEB Wallonia	Mr. Jeroen Panis (ANB); Mr. Nicolas Dendoncker (FUNDP)		Terrestrial ecosystems	Not known yet	To be decided	Not fully known yet, probably including stated preference methods based on Liekens et al. (2012)
Czech Republic	Complete study on grassland ES	Survey of grassland ecosystem services in CR	Iva Honigova (Agency for Nature Conservation)	2010-2011	Grasslands	TEEB	Food provision, climate regulation, invasive species, erosion control, water flow, water filtration, recreation and tourism	Market prices, marginal abatement cost, maintenance cost, damage cost avoided, replacement cost, and stated preference valuation
Estonia	Early development		Lilika Käis (Ministry of Environment)			Not known yet	To be decided	Not known yet
France	Early development	National MA			Terrestrial and marine		43 ES to be analysed	Not fully known yet
Germany	Early development	Natural Capital Germany	Bernd Hansjürgens (UFZ)	2012-2015	All ecosystems	Not known yet	Under investigation	Not fully known yet
Hungary	Early development		Eszter Kelemen (Institute of Environment and Landscape Management)					Not fully known yet

Ireland	Complete study on benefits and costs of biodiversity	Economic and Social Aspects of Biodiversity: Benefits and Costs of Biodiversity in Ireland	Craig Bullock (University College Dublin)	-2008	Agriculture, forestry, marine environment, water, wetlands		Provisioning, regulating and supporting services are considered with less attention to cultural services (with the exception of recreation)	Value transfer
Italy	No on-going national study		Rocco Scolozzi (University of Trento)		Not applicable		Not applicable	Not applicable
Lithuania	On-going national assessment	Lithuanian ecosystem services inventory and valuation	Vytautas Narusevicius (Environmental Protection Agency)	2010-2014	Inland water, forests, wetlands, grassland, cultivated/agric ulture land, peri-urban	TEEB and MA	Provisioning, regulating, cultural, supporting	Market prices, cost-based (substitution) pricing, contingent valuation, value (benefit) transfer, travel costs, hedonic pricing methods
Netherlands	On-going national assessment	TEEB Netherlands	Mr. C.M.A. Hendriks (Alterra) Arjan Ruis (PBL)	2011-2012	All ecosystems	Under investigation	Provisioning, regulating, cultural, supporting	Market valuation (opportunity costs) and possibly nonmarket valuation methods
Norway	Early development	TEEB Norway	Henrik Lindhjem (NINA)	2012-2014	All ecosystems, forests in particular	Under investigation	Provisioning, regulating, cultural, supporting	Unknown yet
Poland	Early development		Andrzej Mizgajski					Unknown yet
Romania	No on-going national study							Not applicable
Slovakia	Early development		Jana Spulerova (Institute of Landscape Ecology)		Not known yet		To be decided	Unknown yet

Spain	Completed national Millennium Ecosystem Assessment	Spanish Millennium Ecosystem Assessment			All terrestrial ecosystems	MA	Provisioning, regulating and cultural services	Limited valuation but VANE project aims to develop this
Sweden	No on-going national study		Louise Hård (Swedish Society for Nature Conservation)					Not applicable
UK	Completed national ecosystem assessment; Follow-on assessment on-going	UK National Ecosystem Assessment	Ian Bateman (CSERGE)	2007-2011	All UK terrestrial and marine habitats	MA adapted to focus on final services	14 ES valued ; a subset of including provisioning, regulating and cultural services	Market prices, damage costs avoided, production function, stated preference, hedonic pricing, meta-analytic value transfer, replacement costs

In over half of the national assessments (53%) the valuation method is not yet clear. In 20% of the ongoing (Lithuania) and completed national assessments (Czech Republic, UK) a combination of market and nonmarket valuation methods are used, including value transfer. The assessment in Ireland is entirely based on existing national value estimates and values from the UK (value transfer). In general, most provisioning services are or will be valued using readily available market prices and where possible regulating services using available (damage or avoidance) cost data. Monetary valuation of non-market ES such as many if not most cultural services found in many ecosystems across EU MS based on non-market valuation methods (e.g. revealed and stated preference studies) seem to pose the biggest challenges. Besides lack of data and information, especially on values for ES for which no direct market prices exist, many assessments also seem to suffer from limited financial resources and environmental economics capacity to conduct original economic valuation research. Monetary nonmarket valuation is furthermore not in every MS an acceptable procedure and subject to ongoing discussion (e.g. Germany, Norway, Netherlands).

Given the early development stage of most national assessments, lessons learned are mainly available from the UK National Ecosystem Assessment (UK NEA), conducted in the period 2007-2011. This was the first analysis of the UK's natural environment in terms of the benefits it provides to society and is currently the most detailed and comprehensive national assessment of ecosystem services. A follow-up phase for the UK NEA is now underway. The main lessons learned from the initial phase of work include:

- The UK NEA was a highly resource intensive assessment, involving a large number of researchers. This scale of assessment will not be feasible for every MS.
- A sound methodological framework for valuing ecosystem services was developed and applied.
- The valuation of ES values in the UK NEA is heterogeneous in terms of the scenarios that are assessed and the methods that are used. The scenarios that are assessed include past trends, current provision, and future scenarios. These scenarios are not valued for all ES addressed in the assessment but examined on a somewhat ad hoc basis depending largely on data availability.
- The valuation methods used include a wide range and encompass different definitions of economic welfare. The consequence of this heterogeneity in both scenarios and methods is that the value estimates for each specific ES cannot be directly compared or aggregated. This is not necessarily a problem for ES specific assessment or policy development but becomes problematic if there is a need to compare and aggregate values across ES (e.g. in national accounting).

- The application of valuation methods takes a pragmatic approach in selecting a variety of methods depending on their applicability to each specific ES and on data availability.

- Certain groups of social values, especially those which are not evident in observable behaviour, cannot easily be measured using currently available economic methods. An example of this might be the spiritual value of the environment, especially where this is linked solely to the knowledge of pristine or intact environments. Related to this, there is debate regarding the ability to derive robust monetary estimates of the non-use (existence) value of biodiversity.

- The flow of ecosystem services makes a considerable contribution to human welfare in the UK. Due to data gaps not all ecosystem services have been valued but those that are illustrate the important role that the natural environment plays in supporting current human wealth creation and wellbeing.

- The UK NEA identifies that a vital area for future investigation is the incorporation of natural resource stocks into economic analyses. This is essential in order to ensure that on-going and future flows of ecosystem service values are sustainable. While theoretical approaches to the economic valuation of stocks are established, there is a significant dearth of information on the size of stocks and, equally importantly, how the flow of ecosystem services from them changes as they deplete. The potential for thresholds, beyond which ecosystem services might more rapidly decline or even collapse needs to be recognised along with the potential for imperfect restoration or irreversible loss.

3. Review of other relevant initiatives

3.1. Overview of other relevant initiatives

Information on other relevant international initiatives on ES assessment and valuation was collected from project reports, websites and through contacting initiative leaders via email and telephone. This section provides a discussion of the initiatives summarised in Table 2 in terms of the steps in the assessment process, ES classification, ES coverage, and the geographic scale of aggregation. Many of these initiatives are on-going and have not yet finished developing or testing their respective methodologies.

3.2. Synthesis and lessons learned

Table 2 shows that momentum for ES assessment is building up. Many ES assessments are starting up and several initiatives are on-going, which still have to report. However, the majority of the reviewed initiatives focus on the mapping or biophysical assessment of ecosystems and services. The number of studies that attempt to integrate across steps in the mapping-valuation-accounting assessment process is very limited. Only three initiatives attempt to cover mapping, valuation and accounting (WAVES, BEES and US NRC), but these are either in an early stage of development (WAVES) or do not aim to produce an integrated methodology.

There furthermore exists a large variation in ES coverage with often limited focus on ES that are less easily quantifiable. The limited harmonisation of ES classifications is troublesome as this is expected to impair future comparisons and linkages. Figure 1 shows the number of initiatives using established ecosystem service classifications.

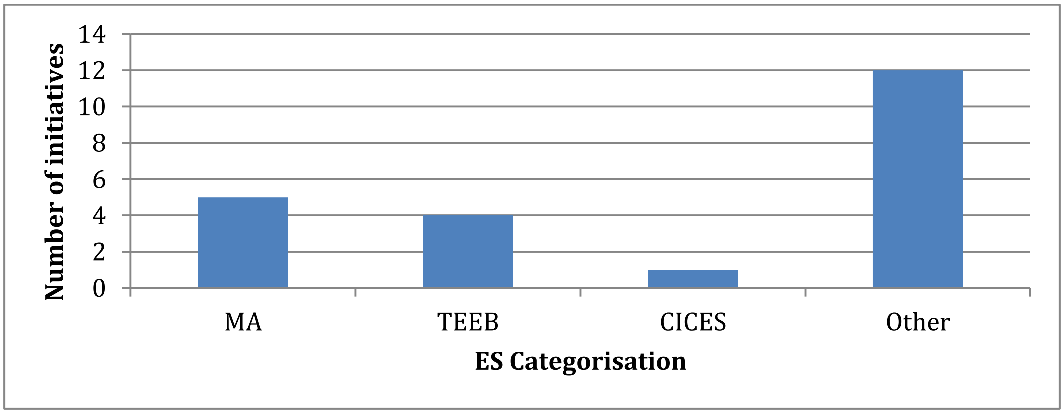

Figure 1. Number of initiatives using common ES classifications

Table 2. List of reviewed initiatives

Acronym	Name of Initiative	Key Institution(s)	Contact Person	Approaches Used	ES Categorisa-tion	ES Coverage	Scale of Aggregation
ALTER-NET	ALTER-NET	26 institutes from 18 European countries (IVM, ALTERRA, ECNC, INBO, IRSTEA etc)	Eeva Furman (SYKE)	Focus groups discussions with stakeholders, use of fuzzy cognitive mapping, computer simulated socio-ecological model based on DPSIR framework, experiments	Unknown/ not specified	habitat/supporting, regulating	EU
AQUAMONEY	Technical guidelines for economic valuation of water resources in the WFD	16 institutes from 14 EU member states (VU-IVM, UEA, Ecologic, Univ Aegean, Univ Bologna, NIVA, Univ Bucharest, RISSAC, BRGM etc)	Roy Brouwer (VU-IVM)	WFD water quality ladder and nonmarket valuation methods (mainly stated preference) based on a common valuation framework to test international transferability of economic values	Water services only not directly based on any categorizatio n	Provisioning (domestic water use), regulating (flood control), cultural (recreation, habitat, e-flow)	Basin, national, EU level
ATEAM	ATEAM – Advanced Terrestrial Ecosystem Analysis and Modelling	Wageningen University, University of East Anglia, PIK, Lund University etc	Wolfgang Cramer (WUR)	Scenario analysis, forest modelling framework, development of several ecological models (e.g. RHESSys, FORCLIM)	Unknown/ not specified	habitat/supporting, regulating, provisioning	EU

BISE	Biodiversity Information System for Europe - BISE	European Commission (DG Environment, Joint Research Centre and Eurostat) and the European Environment Agency	Rania Spyropoulou (EEA)	Data depository	Unknown/ not specified	mainly habitat/supporting	EU
CICES	Common International Classification for Ecosystem Services	University of Nottingham	Roy Haines-Young		CICES	provisioning/regulating and maintenance/cultural	
Eco-Delivery	Eco-Delivery	Stirling University, EIB	Frans de Vries (Stirling)	Lab and choice experiments	Unknown/ not specified	Carbon sequestration, biodiversity, water quality	NA
EEA SCALING-UP	EEA SCALING-UP	EEA, IVM, Ecologic, FEEM	Onno Kuik (VU-IVM)	Meta-analysis; GIS	TEEB	Provisioning/regulating/ cutural	Flexible
ILTER - SEA	ILTER - SEA	LTER networks	Terry Parr (UK Environmental Change Network)	Site-specific feedback models	Unknown/ not specified	habitat/provisioning/regulating/cultural	

JRC Atlas of ES	European assessment of the provision of ecosystem services: Towards an atlas of ecosystem services	JRC	Joachim Maes (JRC)	Mapping of land use and indicator variables; Principal Components Analysis for trade-offs between ES	TEEB	Provisioning, regulating and recreation. Focus is on provisioning and regulating.	EU NUTS3
MA SGA	MA sub-global assessments	WWF Russia, University of the West Indies, World Agroforestry Centre, Norwegian Institute for Nature Research, University of Alasca etc	Cristian Samper		MA	habitat/provisioning/regulating/cultural	
MA	Millenium Ecosystem Assessment	UN, UNEP, UNDP, CGIAR, CMS, CBD, FAO, GEF, ICSU, UNCCD, UNFCCC, UNESCO, WORLD BANK, IUCN, WHO	A.H. Zakri (United Nations University)	Primarily synthesized the findings of existing research, to make them available in a form that is relevant to current policy questions.	MA	Provisioning, Habitat/Supporting, Regulating, Cultural	multi-scale
Natura2000 Assessment	Natura2000 Assessment		Ton Ijlstra (for the Netherlands)	Member states submit data, which are validated by the European Topic Centre for Biological Diversity	Unknown/ not specified	Habitat/Supporting	EU

Natural Capital Project	Natural Capital Project - Integrated Valuation of Environmental Services and Tradeoffs (InVest)	WWF, TNC, Stanford University, University of Minnesota	Emily McKenzie (WWF)	Spatial models (platform in ArcGIS)	MA	All - but models not currently available for: groundwater recharge; agricultural production; flood risk; recreation; fisheries; carbon sequestration	All
PEER	Partnership for European Environmental Research (PEER)	7: Alterra, CEH, IRSTEA, JRC-IES, NERI, SYKE, UFZ	Markku Puupponen (SYKE)	Experiments, field work, simulations.	Unknown/ not specified	Regulating, Provisioning, Habitat/Supporting	
RUBICODE	RUBICODE	University of Oxford, Alterra Wageningen, Lund University, University of the Aegean, University of Tartu	Paula Harrison (Univ Oxford)	Calculation of services in terms of Service Providing Units (SPUs); integrated ecology-economy modelling; dynamic bioeconomic modelling	MA	habitat/provisioning/regulating/cultural	
SCALES	SCALES	UFZ, University of the Aegean, University of Reading, University of Leeds	Klaus Henle (UFZ)	Case-study analyses, historical data on biodiversity and human interactions and development of future projections	Unknown/ not specified	habitat	
TEEB QA	TEEB – Quantitative Assessment	SAC, IVM, PBL, Wageningen, DEFRA, EC DG-ENV, UNEP	Salman Hussein, SAC	Integrated Assessment Model of land use and biodiversity change; Meta-analytic spatially explicit value transfer; Cost-benefit analysis	TEEB	All (but constrained by availability of value estimates in literature)	Global and OECD regions

UK BAP	UK Biodiversity Action Plan	UK Government	John Robbs (DEFRA)	Multicriteria Analysis (quantitative and qualitative data).	Unknown/ not specified	Only Habitat/Supporting Services	UK (England, Scotland, Wales, Northern Ireland)
US EPA	US Environmental Protection Agency	US Environmental Protection Agency	Rick Linthurst	Development of indicators for condition of ecosystems; mapping; ecological risk assessment; development of decision-support tools	MA	mainly habitat/provisioning/regulating	
US NRC	US NATIONAL RESEARCH COUNCIL	US NRC and several US academic institutions	Mark Gibson; Ellen De Guzman; Geoffrey Heal	Multiple valuation methods (e.g. travel cost, stated preferences, production function etc)	Unknown/ not specified	habitat/provisioning/regulating/cultural	
VNN	Valuing Nature Network	University of East Anglia, University of Cambridge, University of Nottingham, Imperial College London, University of York	Ian Bateman (UEA)	Participatory Monitoring, Well-Being Measurements, Statistical model , General equilibrium model, Case study analyses	MA	Provisioning, Habitat/Supporting, Regulating, Cultural	UK (England, Scotland, Wales, Northern Ireland)
VOLANTE	VOLANTE	ALTERRA, Edinburgh University, VU, Copenhagen University etc	Sandra Lavorel (CNRS)	Linking bottom-up and top-down land change models, developing human behavioural models	Unknown/ not specified	habitat/provisioning/regulating	EU member state

WAVES	Wealth Accounting and Valuing Ecosystem Services	World Bank and country parties	Glenn-Marie Lange	Valuation for provisioning & recreational services by market prices; ARIES and InVest for regulating services (see Natural Capital Project)	MA/TEEB	All (in principle)	National

A commonly used classification is still not evident and many initiatives make their own adaptations of existing classifications. This has implications for the potential to standardise and utilise information from existing research efforts, and to make direct comparisons across the results of different initiatives. Bringing together these different classifications will make it difficult to harmonize initiatives at EU level. There is a need for coordination here it seems, which is currently being picked up so it seems by the so-called Maes working group (Maes et al., 2012).

Regarding coverage of ES, most initiatives attempt to address provisioning, regulating and cultural services. The use of these broad categories, however, might conceal significant gaps for specific ecosystem services (e.g. non-use values for biodiversity). It is also the case that initiatives that focus on a particular step in the assessment process often also focus on specific ecosystem services (e.g. initiatives focused on accounting tend to focus on provisioning and regulating services – suggesting that methods for incorporating cultural services in accounting frameworks are absent).

Economic valuation of ES is the prime focus in only a quarter of the 23 reviewed international initiatives (AQUAMONEY, EcoDelivery, EEA scaling up, TEEB QA, US NRC, WAVES). Guidelines for practitioners were written in the EU funded project AQUAMONEY, where an explicit link was established between existing EU policy on ecological and chemical water status (Water Framework Directive), ecosystem services and economic valuation methods. Although many guidelines on economic valuation exist, including general guidelines on ES valuation (e.g. DEFRA, 2007; Pascal et al., 2009; Kumar et al., 2010), no specific guidelines exist directly related to major pieces of EU legislation, their impact on ES provision and related economic values and valuation procedures except those developed in AQUAMONEY.

The model InVEST is applied in two initiatives (Natural Capital project and WAVES). InVEST is a family of tools developed in the Natural Capital Project to map and value the goods and services from nature which are essential for sustaining and fulfilling human life (www.naturalcapitalproject.org). InVEST models are based on production functions that define how an ecosystem's structure and function affect the flows and values of environmental services. The models account for both service supply and the location and activities of people who benefit from services. Currently, InVEST models run as script tools in the ArcGIS ArcToolBox environment. Based on presentations about the tool box, InVEST seems to be primarily a model framework, which can be applied in specific circumstances or case studies based on stakeholder engagement and development of scenarios, which then feed into biophysical and economic models that are or have been adapted to local case study conditions. Besides InVEST, RUBICODE is the only other initiative where bio-economic modeling is applied and ES are included in economic production functions.

Figure 2 shows the number of initiatives in each category of maximum spatial aggregation, i.e. the highest level of spatial aggregation of results that are or will be reported. For the purposes of this study it is encouraging that 8 of the initiatives reviewed use methodologies and data that allow results to be presented at a national scale and that 6 allow reporting of results at the EU level. However, there is a need for combining analysis both at the micro and macro scale. Little reflection currently exists on how to consistently and coherently aggregate or disaggregate across different levels of analysis for different types of ES.

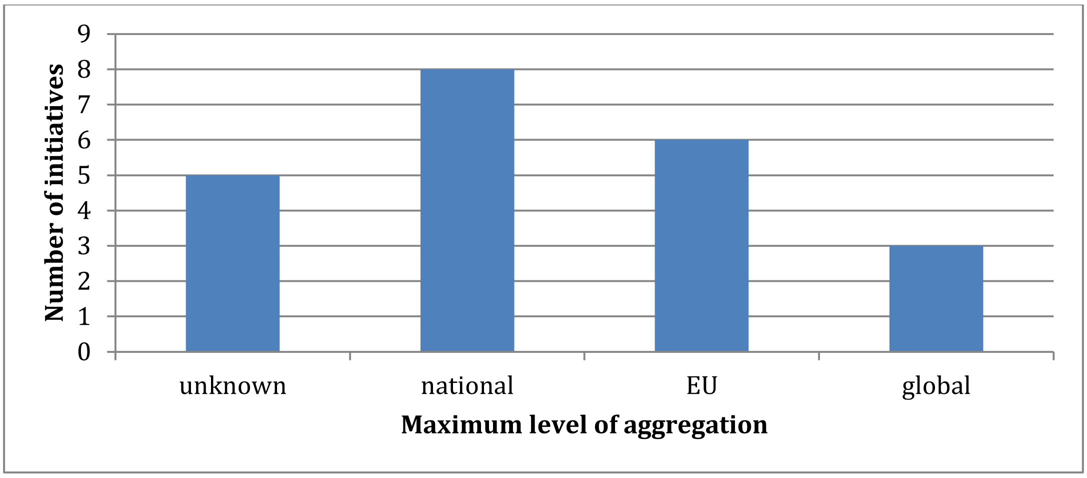

Figure 2. Maximum spatial scale of aggregation

Two initiatives focused specifically on the use of GIS based value mapping and the upscaling of local values for specific ecosystem services to EU MS and EU level with the help of meta-analysis (EEA scaling up and TEEB QA). Experiences in this field using meta-analysis for value transfer are very limited (Brander et al., 2012). Both national and international value transfers require value functions, which control for contextual factors that influence value estimates. For the purpose of upscaling to EU-level, the identification of relevant spatial variables and matching underlying GIS data and information is a crucial intermediate step in value transfer and mapping. However, even under best practice conditions, transfer errors can still be large (Bateman et al., 2011). In order to facilitate the transfer and aggregation of nonmarket values for ES across different scales, the project AQUAMONEY advocates the use of EU-wide standardized environmental quality ladders (Brouwer et al., 2009).

4. Review of green accounting frameworks

4.1. Overview of green accounting frameworks

This section provides a review of the most advanced reporting and accounting initiatives on ecosystem services in Europe and elsewhere. It focuses on the way that these initiatives deal with the monetary valuation of ecosystem services and the changes therein. The descriptions of the initiatives focus on:

1. Operational details: agency, timeframe, ecosystems, ecosystem services, goals, results
2. Valuation: general methodology, specific method per service, (preliminary) results

SEEA Part II on ecosystem accounting

Ecosystem accounting is the latest development in a process of integrating economic and environmental data in one common framework to better inform policy making. The United Nations Statistics Division (UNSD) has played a pivotal role in this process. The first UN Handbook on 'Integrating Environmental and Economic Accounting' was published in 1993. A revision of the so-called 'System of Environmental-Economic Accounts' (SEEA) was published 10 years later in 2003. In 2005, the Statistical Commission of the UN established the UN Committee of Experts on Environmental-Economic Accounting (UNCEEA) with the objectives to mainstream environmental-economic accounts and related statistics; elevate the System of Environmental-Economic Accounts (SEEA) to an international statistical standard; and advance the implementation of the SEEA in countries.

The UNCEEA meets once a year, almost always in New York. The UNCEEA is assisted by various technical groups, including the London Group on Environmental Accounting, Expert Meetings, and Workshops. The SEEA 'Central Framework' was adopted by the UN Statistical Commission in 2012 as the first international standard for environmental-economic accounting. The SEEA 'Central Framework' focuses on the accounting of natural resources such as sub-soil minerals and production forests (hence mainly provisioning services which are traded in markets and for which market prices exist). Work on extensions to the Central Framework, including *Experimental Ecosystem Accounts*, is on-going and is expected to be completed in early 2013.

In 2010 the UNCEEA asked the World Bank, the European Environment Agency (EEA), and the UNSD to develop 'a broad outline and road map for a volume on ecosystem accounting in the SEEA.' This has resulted in a series of meetings among the partners and the presentation of a 'Proposed outline and road map' to the annual SCEEA meeting in 2011. The proposed Road Map consists of the creation of a technical sub group, a series of meetings, the drafting of a framework on ecosystem accounting (SEEA Part II on ecosystem accounting), a worldwide consultation of statisticians, economists and scientists in the fourth quarter of 2012, and the presentation of the final version of the SEEA Part II on ecosystem accounts to the UNSD in February 2013.

In this process there is strong collaboration with the London Group on Environmental Accounting and also with the UK Office for National Statistics (ONS) and the UK Department for Environment, Food and Rural Affairs (DEFRA), who are, on a parallel track, engaged in including natural capital in the UK Environmental Accounts, with early changes by 2013, as a response to the commitment of UK *Natural Environment White Paper* of 2011.

Other processes with links to the revision of the SEEA include the Millennium Ecosystem Assessment, The Economics of Ecosystems and Biodiversity (TEEB), the 'Stiglitz Report' on measurement of economic performance and social progress, and a number of regional emerging projects such as Europe's 'GDP and beyond'.

UK ONS

The Natural Environment White Paper (2011) includes the following commitment:

"We will put natural capital at the heart of Government accounting. We will work with the Office for National Statistics to fully include natural capital in the UK Environmental Accounts, with early changes by 2013. In 2012 we will publish a roadmap for further improvements up to 2020."

The Office for National Statistics (ONS), working closely with DEFRA, will engage fully in the international developments on experimental ecosystem accounts; and it will work closely with experts and users in the UK to inform the development of the roadmap. Early initiatives include a pilot study in 2012 to produce forestry accounts. This pilot study will use the SEEA Central Framework, but *explore* the production of a full ecosystem account. Land use and cover accounts will be produced by 2013 (Khan, 2011).

WAVES

WAVES is an initiative of the World Bank to implement green accounting in a critical mass of countries, both developed and developing. The project was launched in October 2010 at the CBD meeting in Nagoya and will last five years. The first two years are the preparation phase to establish the global partnership, to establish a Policy and Technical Experts Committee, and conduct feasibility and planning studies in pilot countries. The implementation phase of the project is from 2012 through 2015. Partner countries currently include: Botswana, Colombia, Costa Rica, Madagascar, the Philippines, Australia, Canada, Japan, Norway, and the United Kingdom. Mauritius will join with funding provided directly by France.

"The partners want to take natural capital accounting beyond the SEEA-approved material resources, such as timber and minerals, to include ecosystem services and other natural resources that are not traded or marketed and are therefore harder to measure. That

includes the "regulating" services of ecosystems, such as forests for pollination and wetlands for reducing the impact of floods. A Policy and Technical Experts Committee, working closely with the processes set up by the UN Statistical Commission, has been established to take this forward." (http://www.wavespartnership.org/waves/natural-capital-accounting?active=2)

The country plans are driven by the countries' needs and preferences. Each partner country is developing a road map to take the initiative further. For Botswana and Madagascar the road map includes developing and implementing macro-indicators such as the Adjusted Net National Income and the Adjusted Net Savings. In addition, the focus in Botswana is on energy resources and energy use, ecosystem-based tourism, and water accounts. In Madagascar the additional focus is on mining, river basins, ecotourism, coastal zone management, and fishery accounts. The other countries have also presented progress reports on the recent second WAVES partnership meeting Washington D.C.: http://go.worldbank.org/O3A2TJSP30

The approach towards the valuation of non-marketed goods and services is spatially-explicit and demand-based. The challenge to use spatially-specific and demand-based value estimates for national accounting is best described by the World Bank itself:

"The power of the national accounting approach is to provide an economy-wide picture of the value of ecosystem services. There are many challenges to incorporating natural capital in a national accounting framework, due to the unique characteristics of natural capital. Many case studies of ecosystem services have been done, but there remain many gaps where services are not covered. In some cases, these gaps can be filled by scaling out or borrowing values from other studies. But the value of many ecosystem services is highly site-specific, which makes gap filling and scaling out a potentially complex undertaking. To address this, country implementation teams will be encouraged to seek and use values from local or sub-national case studies for ecosystem services, and identify reasonable methods for scaling up local value to fill data gaps. Technical advice will also be provided to draw on meta-data analyses, and ecosystem models such as InVEST from the Natural Capital project, ARIES or local models to do this." (World Bank, 2011).

It is also one of the tasks of the Policy and Technical Experts Committee to think about how case study value data can be aggregated, scaled-up and reported in National Accounts (Lange, 2011b).

EEA

The European Environment Agency has developed a framework for Simplified Ecosystem Capital Accounts (SECA) (Weber, 2011). The basic statistical unit is the Socio-Ecological Landscape Unit (SELU), derived from the Corine land cover maps and additional geo-environmental information on a 1km grid. The main division of landscape units is between mountains, highlands, lowlands, coasts, and rivers. The terrestrial landscapes are subdivided in urban areas, broad pattern agriculture, agricultural associations and mosaics, pastures and natural grasslands, forest tree cover, other dominant natural land cover, and composite land cover.

Within these landscape units, SECA focuses on three groups of services: biomass/carbon production, freshwater production and functional services. The latter measure the capacity or potential of ecosystems to deliver ecosystem services in a sustainable way.[2] A final composite index is the Ecosystem Potential Unit Equivalent (EPUE).

The monetary valuation approach of SECA is related to the concept of Consumption of Fixed Capital (CFC). Translated to ecosystems this refers to the depreciation of ecosystem capital. The EEA gives a few examples of this depreciation: “the cost of keeping below the maximum of 2 degrees global warming target”, “REDD (Reducing Emissions from Deforestation and forest Degradation) payments”, and “the costs of remediation measures to restore or maintain ‘good environmental quality of the river basins’ under the Water Framework Directive”. Unit costs per EPUE are to be derived by experts from the analysis of real expenditures or costs of restoration programs. “Estimates of unitary costs have to be carried out by ecosystem types/issues/regions” (Weber, 2011, p.23).

It is explicitly stated that compatibility with the System of National Accounts (SNA) excludes some methods of valuation that are frequently used in cost-benefits analysis – “typically contingent valuation” – because of different definition of value itself (transaction prices versus willingness-to-pay) and up-scaling and aggregation issues.

Statistics Netherlands

Statistics Netherlands has a long history in developing and implementing integrated environmental-economic accounting. In the beginning of the 1990s, parallel to the publication of the UN’s first handbook on integrated environmental and economic accounting (SEEA), Statistics Netherlands extended the National Accounting Matrix (NAM) with a ‘satellite account’, which includes the environmental pressures related to the production of goods and services and the consumption of households. This resulted in the National Accounting Matrix including Environmental Accounts (NAMEA) (de Haan et al.,

[2] This is measured by indicators such as the Green Background Landscape (GBL) index, the Mesh Effective Size (MEFF) index, the Sated Social Nature Value (SSNV) index, the Landscape Ecosystem Potential (LEP) index, etc.

1993; de Haan and Keuning, 1996). The NAMEA provided the basis for a Dutch Government commissioned comprehensive macro-economic modelling exercise using an applied general equilibrium model by Gerlagh et al. (2002) to estimate a sustainable national income measure for the Netherlands based on the macro-economic adjustments needed to meet ecological threshold values, which were considered crucial to sustainable environmental development.

Based on the NAMEA and linked to the implementation and reporting requirements of the EU WFD, an integrated water accounting system was developed in 2004, called National Accounting Matrix including Water Accounts for River Basins NAMWARiB (Brouwer et al., 2005). Physical water and pollution flows are linked in this system of integrated accounts to the core System of National Accounts, and disaggregated to the different river basins in the Netherlands using GIS. Time series linking financial transactions in economic sectors to water abstraction, wastewater discharge, corresponding pollution loads of close to 100 chemical substances (including nutrients, heavy metals and other chemical compounds which are systematically monitored in Dutch water bodies), and wastewater treatment are available since 1996. Annual financial flows related to the water services as defined in article 2 in the WFD (about which MS have to report cost recovery rates to the European Commission) are distinguished explicitly in NAMWARiB. This integrated water accounting system was the basis for another macro-economic modelling exercise using an updated version of the existing applied general equilibrium model for the Dutch economy to estimate the macro-economic and sector impacts of different WFD implementation scenarios (Brouwer et al., 2008; Dellink et al., 2012).

Following the NAMWARiB methodology, also the contribution of services provided by the North Sea ecosystem to the Dutch economy were assessed (Statistics Netherlands, 2011; Vuik et al., 2011). The geographical boundaries of the latter study are defined by the Dutch part of the Continental Shelf, seaports, and coastal zones (defined as all zip codes that overlap with the coast line). Multipliers derived from input-output analysis are used to estimate spillovers (in terms of employment, production and value added) from seaports to the rest of the economy. Production activities at sea include oil and gas extraction, fisheries, sea shipping, wind power, and sand extraction. For the seaports and coastal zone only these activities are included for which proximity or accessibility to the North Sea is assumed to be a critical location factor. For seaports they include: manufacturing, transport, construction, oil and gas production, and wholesale trade. For the coastal zone they include: fishing, retail trade, restaurants/hotels, culture and sports activities. Data on employment, production and value added were mostly taken from the national accounts system, augmented with data from other government and quasi-government agencies. In terms of ecosystem services, the study focuses on provisioning services and amenity services (as an input to the recreation sector). The study does not assess non-market services that our outside of the production boundaries of the current SNA (e.g. amenity services that are directly enjoyed by visitors). In terms of the UK NEA, the study assesses the value of the “welfare-bearing goods” that are produced by the marine ecosystem services augmented by human and manufactured capital inputs. It makes no attempt to “isolate” the contribution of the ecosystem services to the production of those goods (Bateman et al., 2011). It nevertheless shows the importance of the North Sea ecosystem to the Dutch economy.

Very recently the Agricultural Economics Research Institute of the Netherlands (LEI) started carrying out a study on natural capital accounting on behalf of the Ministry of Economic Affairs, Agriculture and Innovation. The study focuses on the value of ecosystem services for the sectors water, recreation, and raw chemical industry. The study is in an early stage of execution; therefore little is known about the methodological choices that will be made. The study was preceded by a brief note that summarizes Dutch and international thinking on indicators to assess the value of ecosystems (van der Heide et al., 2012).

Agro-forestry Accounts System (AAS) in Spain

In Spain, a group of researchers developed and tested an Accounting System for agro-forestry ecosystem services (Campos and Caparrós, 2006; Caparrós et al., 2003). The accounting unit is a forest ecosystem, e.g. the Mediterranean *Monfragüe* cork oak forest or the *Guadarrama* pine forest. Services accounted for are timber, cork, firewood, grazing, hunting, wild mushrooms collected, public recreation, and conservation (existence) value. It also includes a value category called “owner’s self-consumption of environmental services”.

The innovation of the Agro-forestry Accounts System (AAS) is the way in which shadow prices for the non-marketed good and services (e.g. mushrooms, public recreation) are estimated. Standard benefits estimates would measure consumer surplus over a change in the level of provision of service. Consumer surplus is not consistent with SNA, however. SNA values goods and services by exchange values (prices). Therefore Campos *et al*. estimate the income that would be earned in a hypothetical market where ecosystem services would be bought and sold. They estimate hypothetical demand and supply curves for the ecosystem services and make further assumptions on the price that would be charged by a profit maximizing resource owner under alternative market structures (monopoly, competition). Campos *et al*. call this the Simulated Exchange Value approach. The hypothetical income of the resource owner thus derived is consistent with the general valuation approach of the SNA.

Another difference is that Campos *et al*. include government expenditure in the forests as a cost rather than as output (as is standard in SNA) because, as they argue, the lion’s share of government expenditure in forest in Spain is fire fighting and this has a direct impact on commercial timber output. The fire fighting service is therefore already (to a certain extent) valued by the ‘saved’ timber output. To avoid double counting, government expenditures are therefore only recorded at the cost side.

MEGS (Measurement of ecosystem goods and services – Canada)

Measuring Ecosystem Goods and Services (MEGS) is a Canadian interdepartmental project to develop statistical infrastructure to support the valuation of ecosystem goods and services and create pilot ecosystem accounts (Wang et al., 2012). MEGS provides C$ 2.25 million in funding for Statistics Canada over 3 years to develop prototype ecosystem accounts to support policy needs of Environment Canada, Agriculture and Agrifood Canada, Fisheries and Oceans Canada, and Natural Resources Canada (Bordt, 2012).

The initial plans for MEGS are to develop a table with ecosystems, their respective areas and quality measures (stocks) and monetary values of ecosystem goods and services per hectare (flows), grouped according to CICES classifications. The accounts would be spatially nested, allowing the presentation of data at different ecosystem classification levels (Wang et al., 2012). Wang et al. (2012) present an assessment of positive and negative aspects of various accounting and valuation approaches linked to policy applications, which provides a useful starting point for further discussion (see Annex 3).

Australia - Accounting for Nature Project

The Accounting for Nature project compares the current condition of an environmental asset or an indicator of ecosystem health to a reference benchmark condition. The benchmark condition can be the condition of the ecosystem/landscape at a fixed point in time (e.g. condition prior to industrial development), or the condition of naturalness estimated by a scientific model. The difference between the current condition and the benchmark condition is measured by an index. This index ranges between 0 (ecosystem function is absent) to 100 (benchmark condition). In the *Accounting for Nature* project, the index numbers are called ECOND. The ECOND is the common environmental currency by which the health of different ecosystems (ecosystem services) in different locations and times can be compared (Cosier, 2011).

In 2011, regional natural resource management bodies in 10 watersheds in Australia, assisted by the Australian Bureau of Statistics, Australian Board of Meteorology, CSIRO, the Wentworth Group of Concerned Scientists and independent experts, started a 'proof-of-concept' trial of the *Accounting for Nature* model (Cosier and McDonald, 2010; Cosier, 2011).

4.2. Synthesis and lessons learned

There are a number of on-going initiatives that aim to develop recommendations for integrated natural capital accounting and the incorporation of ecosystem service values in national accounts. These initiatives are at various stages of development and closely linked to already existing satellite accounting systems around the core SNA in several countries, focusing primarily on provisioning services like timber and natural capital like subsoil minerals. An important question is to what extent ES can be fully integrated into the core SNA or included as satellite accounts around the SNA, either in physical or monetary terms. The approach taken will (or should) ultimately depend on the question one would like to see answered. The SEEA guidance on ecosystem accounting is likely to encompass a broad description of the conceptual framework, which will include discussion on the scope and purpose of the accounts along with the proposed accounts, the classification of ecosystem services, the definition and measurement for the ecosystem accounting units and the valuation and recording methods of physical and monetary flows and stocks (United Nations Statistical Division, 2011).

An important issue for accounting is the distinction between ecosystem services whose values are already implicitly accounted for in conventional SNA (e.g., pollinators to agricultural production) and those services whose values are not (e.g., free access recreation in nature areas). In the former case, the challenge is mainly attribution: what fraction of value added of a sector or the economy should be attributed to what ecosystem services? In the latter case, conventional GDP will be augmented by hitherto unpriced goods and services (e.g., carbon storage or flood protection by wetlands) (Anon., 2011).

For the ecosystem services within the *production boundaries* of SNA (these that are implicitly accounted for), market prices can be used to calculate their values. However, in theory one would need to rely upon empirically estimated production function approaches (e.g. bio-economic modelling) to assess the marginal value of the ecosystem service involved. For other ecosystem services, where such market prices do not exist, it is necessary to "conduct valuations at a scale which is feasible, credible and policy relevant. In order for these valuations to be consistent with the SNA, they will need to approximate prices, and not to attempt to represent a holistic or social identity of value" (United Nations Statistical Division, 2011, p.9).

There are different views on what valuation methods are "feasible, credible and policy relevant". Weber (2011) for example, asserts that "compatibility with SNA excludes some methods frequently used in cost-benefit analysis (typically contingent valuation)..," and proposes to use "remediation costs" to value the degradation of ecosystems. In contrast, UK NEA, has, for reasons of consistency with economic theory, "excluded the use of restoration or replacement costs as a proxy for the value of ecosystem services"(UKNEA, 2011, p. 1072).

Glenn-Marie Lange of the WAVES project summarizes this issue as follows: valuation techniques must stay within the SNA concept of value, that is: market-based/marginal. Cost-based, remediation, approaches are “third-best” (Lange, 2011a). The Simulated Exchange Value approach of Campos and Caparrós (2003; 2006) presents an interesting attempt to bridge the conceptual gap between welfare economics and SNA. The table of Wang et al. (2012) of Statistics Canada on linkages between accounting approaches, valuation methods and policy applications (see Annex 3) provides a potentially useful starting point for further discussion.

Finally, it may be useful to put these ongoing initiatives in a historical perspective. The discussion about greening the SNA is an old one, going back to the 1960s-1970s, where economic growth models provided the theoretical basis for measuring progress towards sustainable development and greening the National Accounts (e.g., Solow, 1974; Hartwick, 1977; Pearce and Atkinson, 1993; Asheim, 1994). Several initiatives were developed using ad hoc “correction mechanisms” (typically consisting of the subtraction of so-called environmentally defensive expenditures and depreciation of natural capital) to arrive at adjusted national income measures like the Index of Sustainable Economic Welfare (ISEW). In this rather old discussion, the imputation of monetary values to all market and nonmarket flows of benefits and damages from natural resources and ES during past, present and future periods of economic activity (that some of the ongoing initiatives reviewed here seem to head towards) is but one way to inform policy and decision-making about society’s progress towards wider macro-economic welfare and well-being. Alternative approaches were explored in a number of EU funded research projects, among which the project GREENSTAMP (Brouwer et al., 1999). In the latter project, full monetization of all flows of ES and natural capital degradation in the core SNA for the purpose of estimating a green or sustainable GDP was questioned due to (i) the contrasting hypothetical nature of such an exercise and resulting sustainability measure vis-à-vis the actual financial transactions currently monitored and reported in the SNA, and (ii) the assumptions needed to be made that everything else in the economy would remain the same if nonmarket ES and natural capital degradation would be monetized and exchanged in markets like the rest of the marketed produced goods and services currently monitored and reported in the SNA. Instead, a macro-economic modelling approach was proposed based on an integrated accounting system (linking the SNA to a set of physical satellite accounts) to assess the necessary macro-economic and sector adjustments needed to reach environmental standards associated with different levels of ES provision, distinguishing between ex post (how the economy would have looked like if ES would have actually been accounted for in existing market systems) and ex ante (how the economy can look like in the future if ES are accounted for in existing market systems) sustainable development paths.

5. Surveys of practitioners and experts

Two surveys have been conducted among key experts and stakeholders in order to obtain additional detailed opinions on the key methods, data, capacities and challenges related to ecosystem service mapping, valuation and accounting. The results of these surveys are presented in this section.

5.1 Survey of participants at the TEEB conference 2012

The first survey targeted participants of the TEEB conference 2012 in Leipzig (19-22 March 2012). A flyer was included in all welcome folders distributed to conference participants, introducing them to the survey objectives and providing the survey link (http://ivm30.ivm.vu.nl/teeb). The TEEB conference organisers sent two rounds of email reminders to participants in order to increase the response rate. Annex 2 provides the questionnaire that the research team compiled for the purposes of soliciting information from the conference participants. The questions are designed in order to obtain information on the objectives, theoretical framework, coverage of ecosystem services, links with bio-physical modelling, valuation approaches, scaling up, accounting and reporting, results, policy impacts, and any lessons learnt. Responses are combined with the academic background of survey participants, institutional affiliation, involvement in TEEB initiatives and geographic area of expertise. Thirty-one experts filled in the online survey ranging from academic researchers to consultants and public officials.

When asked how much progress they believe has been made in different fields, linking for example biodiversity to ecosystem services, ecosystem services mapping and valuation or developing a common framework, a majority believes some progress has been made, especially the development of a common framework for economic analysis of biodiversity and ES (Figure 3). However, more than a third of all respondents (35%) are rather sceptical when asked how much progress has been made with the integration of the concept of ES in European or national policy and decision-making. Respondents are most positive about progress that has been made since the start of TEEB linking biodiversity to ecosystem services. Almost a quarter (23%) is of the opinion that a lot of progress has been made in this particular field. Just less than 20% of all respondents believe that a lot of progress has been made on quantifying, mapping and valuing ES.

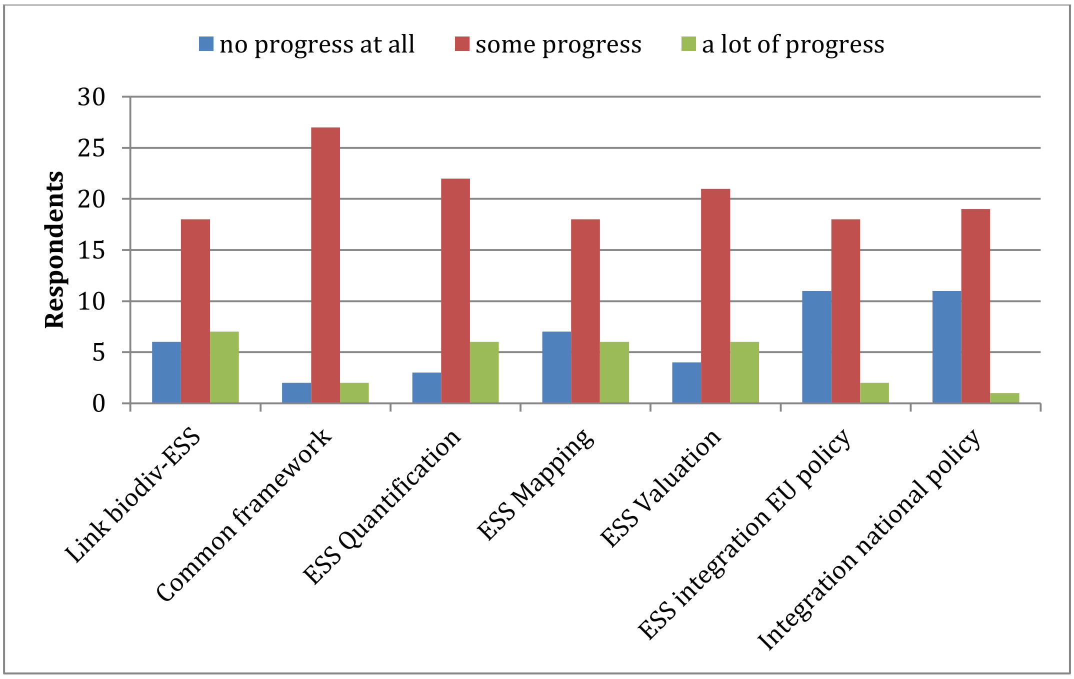

Figure 3. Perceived progress since start of TEEB

Although a majority of respondents indicated that some progress has been made since the start of TEEB towards creating a common framework for the economic analysis of biodiversity and ecosystem services, only 5 out of the 31 respondents (16%) said that such a framework already exists. Two of these respondents refer to the Dutch government guidelines on cost-benefit analysis for external effects, while the others refer to existing Payments for Ecosystem Services (PES) schemes without providing further detail, except in the case of Peru where there is an obligation to include the economic benefits of ecosystem services in environmental impact assessments. PES are also mentioned a number of times when asking respondents if they can indicate whether a practical policy instrument had been developed and implemented towards the protection of biodiversity and ecosystem services based on TEEB.

Most respondents consider awareness raising and improving cost-benefit analysis to support environmental policy and decision-making the most important roles of economic valuation in sustainably managing biodiversity and ecosystem services (Figure 4). The role of economic valuation in green accounting, improving environmental justice and alleviating poverty is considered by most respondents least important (approximately 25% does not consider this important at all). A majority of around two thirds consider valuation important for setting taxes or subsidies and fixing compensation in environmental liability.

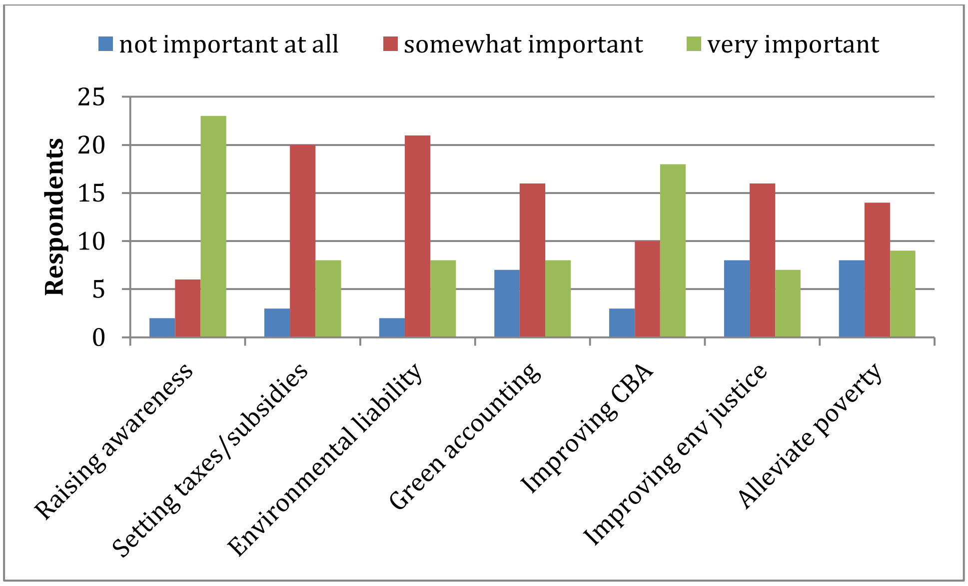

Figure 4. Perceived importance of economic valuation for different purposes

When asked how important different challenges are of including economic values for biodiversity and ecosystem services in national or EU accounting frameworks, lack of understanding of ecosystem functioning and provision of services was considered most important by a majority of respondents (65%), followed by the limited priority given to this by policy and decision-makers (61%). This is presented in Figure 5.

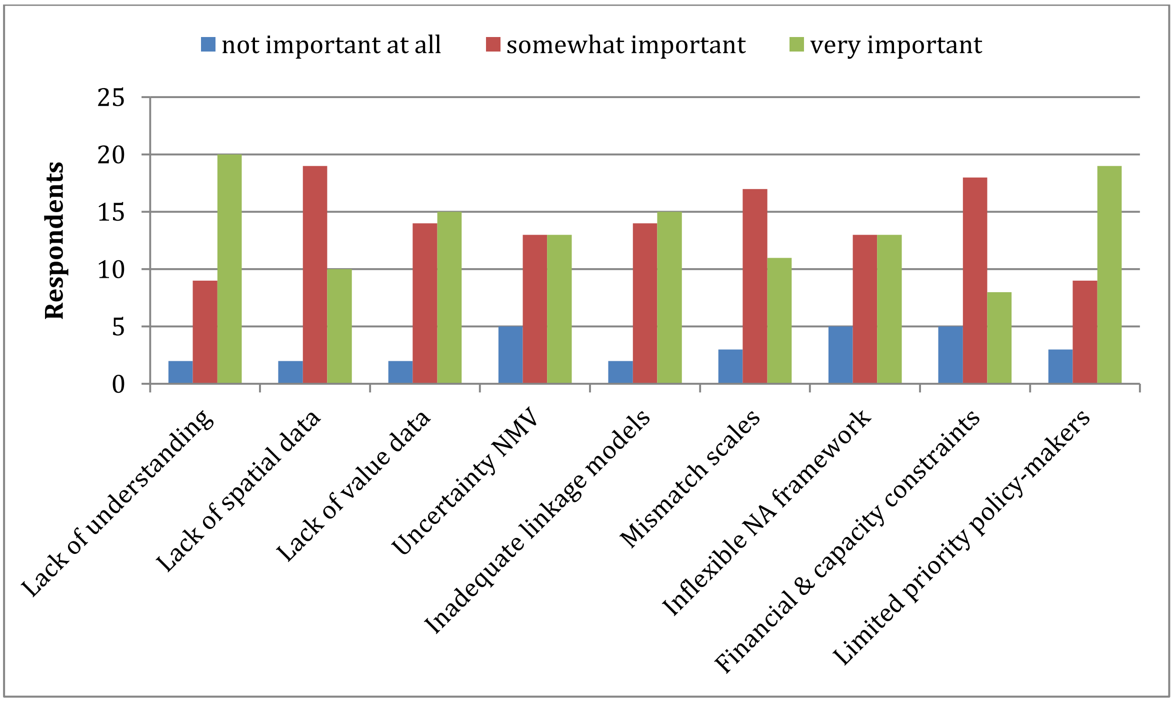

Figure 5. Perceived importance future challenges

Almost half of all respondents (48%) consider the lack of data on the values of ecosystem services and biodiversity very important and the inadequate linkage between biophysical and economic models. The uncertainty associated with the precision of non-market valuation (NMV), inflexible national accounting frameworks, and financial and capacity constraints at the national level are considered not important at all by 5 of the 31 respondents (16%).

Finally, according to the 31 respondents, the most important future research priorities for valuing and accounting for biodiversity and ecosystem services at national and EU level (elicited in an open ended question) are presented in the list below. The development of a common framework was considered most important by most respondents, followed by the improvement of valuation methodologies, and insight in the trade-offs between biodiversity and ecosystem services.

Respondent future research priority list:

1) Development of a common framework
2) Improvement of economic valuation methods
3) Improve insight in trade-offs between biodiversity and ecosystem services
4) Improve accounting practices, also for companies
5) Translate research results to practical policy and link values to policy action
6) Other: creation of public awareness, creation of economic incentives, managed ecosystems, cultural services in urban areas

5.2 Survey of experts

A second online survey targeted identified experts in the fields of ecosystem service valuation and accounting. The research team compiled a long list of experts in valuation of ecosystem services, biodiversity and accounting, based on the review of relevant initiatives. Annex 3 provides the questionnaire that the research team prepared for the purposes of soliciting information from the key experts.

In total 18 experts completed the survey. The results are described below. When asked to rate the challenges that need to be addressed in mapping and assessing the state of ecosystems and their services at the national scale (on a scale of 1-5, with 1 = not important; 5 = very important), respondents rated the lack of data on the spatial distribution of ES as the most important challenge (average rating 3.9). The adequacy of existing classifications of ES was considered to be of low importance (average rating 2.1). There is evidently a commonly held view that the existing classifications of ES are adequate for biophysical assessment and mapping of ES. Figure 6 presents the average ratings for six potential challenges.

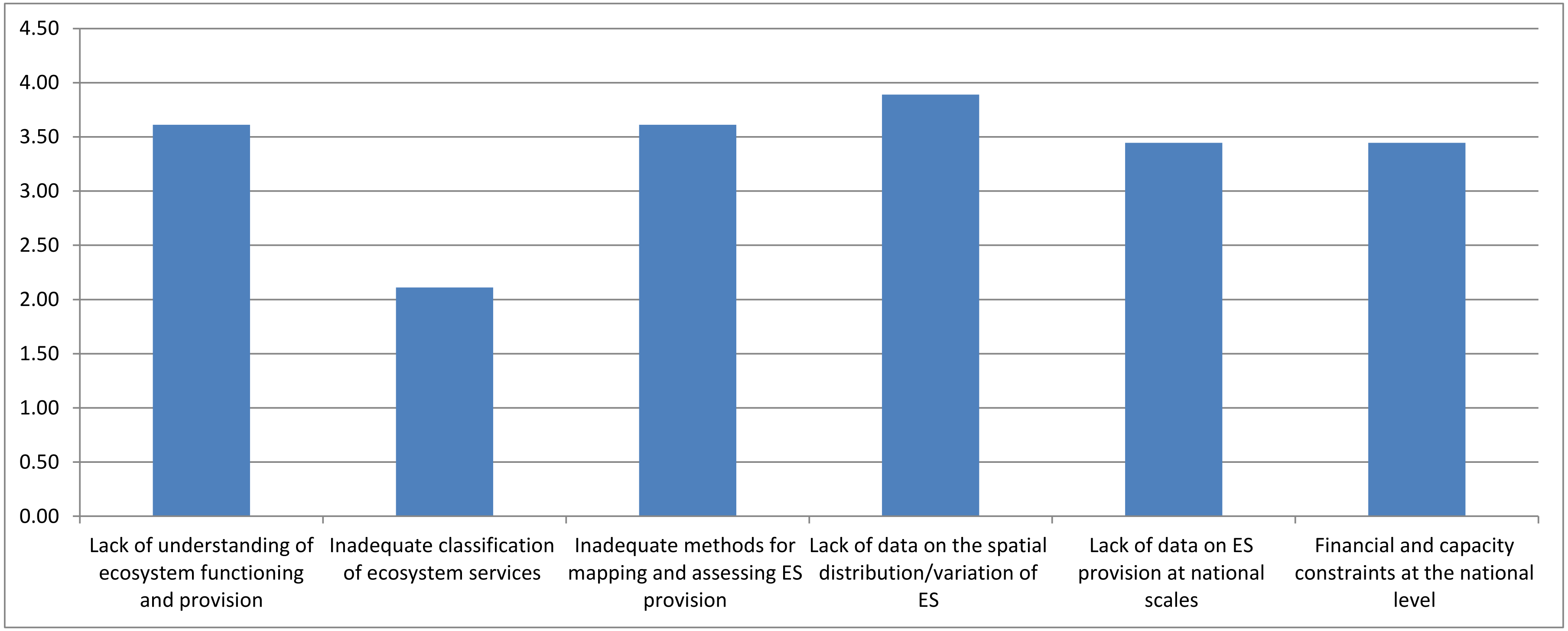

Figure 6. Expert opinions on the most important challenges to be addressed in **mapping and assessing** the state of ecosystems and their services at the national level (1 = not important; 5 = very important).

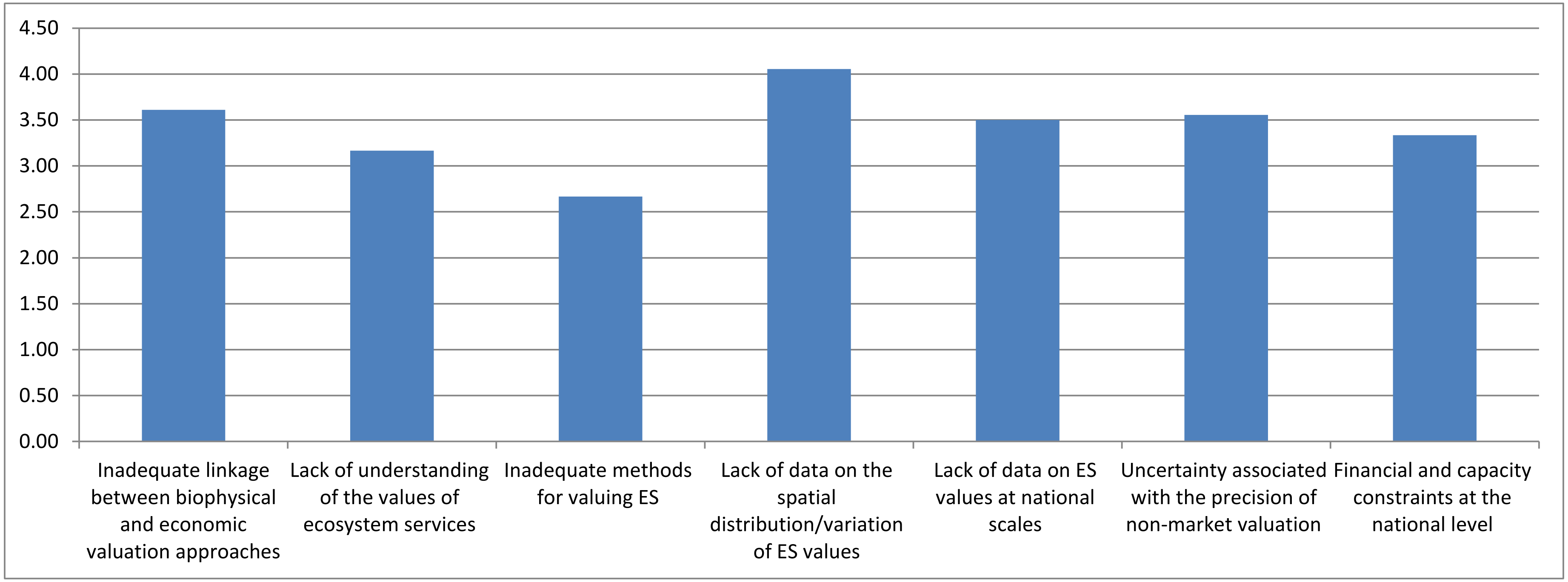

Figure 7. Expert opinions on the most important challenges to be addressed in **assessing the economic value** of ecosystem services at the national level (1 = not important; 5 = very important).

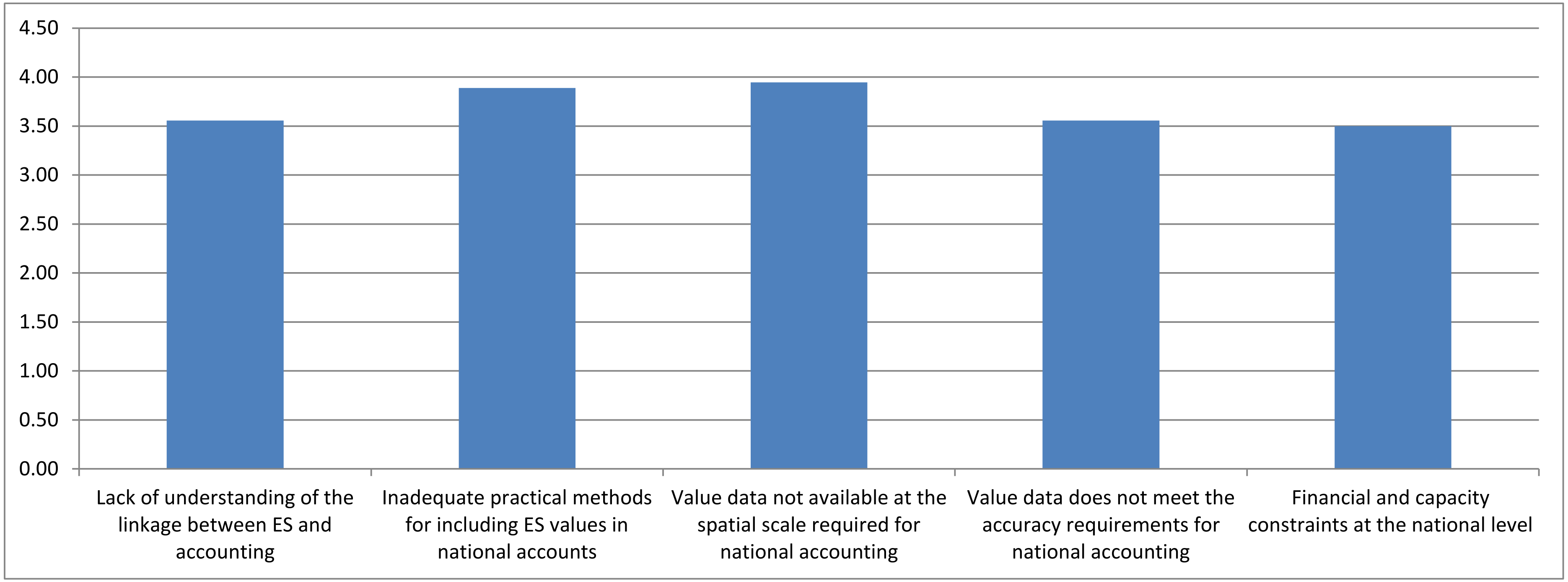

Figure 8. Expert opinions on the most important challenges to be addressed in **integrating ES values into accounting and reporting systems** at the national level (1 = not important; 5 = very important).

Additional challenges to be addressed in mapping ecosystem services identified by survey respondents include:

- Consistent methods to enable comparison between MS
- Lack of information on marine ecosystem services
- Political buy-in to incorporate this info into decision making
- ES vary from place to place e.g. because of varying demand
- Uncertainty acknowledgement in ESA
- Exact purpose and benefits unclear, lack of joint demand across sectors
- Lack of knowledge about the IMPACTS on ES from different causes
- Difficulties in linking land use change to ES supply
- Lack of spatially representative social science data on use of nature

Regarding expert opinions on the challenges to be addressed in valuing ES at the national level, Figure 7 presents the average ratings for seven recognized challenges. The lack of data on the spatial distribution/variation in ES values is considered to be the most important challenge (average rating 4.0), followed by inadequate linkage between biophysical and valuation approaches (average rating 3.6) and uncertainty associated with valuation results (average rating 3.6). The adequacy of methods for estimating monetary values was considered to be the least challenging issue (average rating 2.7).

Additional challenges to be addressed in valuing ecosystem services identified by survey respondents include:

- Problems in reconciling different methods of ES valuation
- Lack of reliable, large scale valuation studies for key habitats/ES
- Understanding how to APPLY the ES value info to alter decisions
- Lack of interest at the national level policy-making
- Uncertainty associated with the precision of market valuation
- Exact purpose of valuation, adequate use of methods e.g. citizen vs. consumer perspectives
- Lack of methods for linking non-monetary and monetary valuation
- Methods for valuing ES not spatially sensitive to incremental changes

The respondent ratings of the challenges to be addressed in integrating ES values into accounting and reporting systems at the national level are presented in Figure 8. Again, it is the availability of data at the appropriate spatial scale for national level assessment that is considered to be the most important challenge (average rating 3.9). This is followed by the adequacy of practical methods for including ES values into national accounts (average rating 3.9).

Additional challenges to be addressed in integrating ES values into accounting systems identified by survey respondents include:

- Existing valuation data often not collected for well-defined ES
- Lack of agreed UN guidance (if not proper standards)
- Willingness to include landscape scale info to inform national account
- Difficulty in transferring the importance of ES values to policy-making
- Robust method which captures complexity in understandable way
- Lack of conviction beyond the environmental sector on why this is important
- Decision on whether we are referring to satellite or full integration
- Theoretical adjustments probably impossible with real data

Survey respondents were asked to identify the most important future research priorities for quantifying, mapping, valuing and accounting for ecosystem services at the national level. The responses largely reflect the challenges identified above and have been grouped according to the step in the assessment process that they address:

Biophysical assessment and mapping:

- Link between causes and the impact on ES, i.e. dose-response functions to establish physical impacts of different drivers
- More models linking change in land use to change in ES supply
- Agreement on a common classification and common indicators/proxies for all ecosystem services
- Biological information about ecosystem functioning and services
- Mapping and assessing selected services that did not receive much attention until now (medicine provision, habitat services, many cultural services)
- Mapping inter-relationship between different drivers of change and scenarios created on the basis of it regarding ES
- Mapping and valuation of urban ecosystem services
- Monitoring programmes to provide consistent long-term spatial data on all ecosystem service indicators

Valuation

- Valuing services at a level of accuracy that is acceptable for accounting purposes
- A broader range of large-scale and/or spatially referenced ecosystem service valuation studies (e.g., along the lines of SEER-CSERGE)
- Combining different valuation methods in one framework
- Research on linking deliberative methods for non-monetary valuation with monetary valuation
- Spatial non-market valuation
- Visualizing the location and value of ES providing areas and the areas creating demand for ES
- Identifying cultural services
- Stocks versus flows maybe conflated - this needs guidance

- Production function based valuation of regulation functions
- Issues of scaling up remain and probably not fully dealt with in meta-analysis
- Geographical aggregation of values to national and international scale - the adding-up challenge
- The risk of double-counting in valuation according to the ES framework
- Handling the adding-up problem (substitution in values across/within ES)
- Hybrid (e)valuation methods accounting for different value dimensions in decision-making
- Transfer of economic values over time
- Better determination of accuracy and reliability requirements of valuation for different policy settings

Accounting

- Agreement of methods (WAVES etc.) - there is a long history here in satellite accounting - just needs to be bottomed out

Linkages between steps in the assessment process

- Understanding how ecosystem processes and services interact to produce goods that can be valued
- Increase fundamental understanding of the mechanisms underpinning ES delivery: ecological mechanisms AND valuation mechanisms (how are values constructed?)
- Link between biophysical services and welfare impacts
- Devising flexible systems that start with rough draft but allow entering more specific information and further refinement as this becomes available
- Linking biophysical and monetary values of ecosystem services to biodiversity (role of biodiversity in underpinning services)
- Defining linkages between physical measures of ecosystem services and value measures
- Reconciling different sources of values (SP based consumers' surplus; market and RP based prices; costs, production functions etc) in accounting
- Enabling national scale assessments in framework that can fit national accounts / monitoring and comparing change across countries
- Link between impact on ES and economic valuation
- Linking biophysical, economic and social methods for spatially-explicit assessment of ecosystem services
- Local rooting of data on delivery & demand

Other research priorities

- Development of a consistent approach that can be practically applied in all MS
- Feeding information into decision-making at multiple scales - from local to national to global

– Understanding the importance of and need for ES in changing climate
– Develop a TEEB national program with sufficient funding for all issues indicated as important
– More mapping and valuation of ecosystem services for the marine environment
– Appropriate data basing at national scale: address uneven data availability across countries; data at fine resolution relevant to processes
– Acknowledging uncertainty
– Involving a broad set of stakeholders in the procedures to achieve not only buy in but the necessary specifications to make the entire exercise useful
– Modelling the importance of uncertainty in knowledge about ecosystem service values and policy decisions
– Better understanding and being able to deal with the multilevel and interactional nature of the problems and designing robust methodologies for this

Respondents to the survey were further asked to provide their opinions on the sufficiency of technical capacities within MS and the feasibility of integrating ecosystem service values in national accounts by 2014 and 2020. A summary of responses is given in Figure 9. Respondents to the survey represent nine MS, with multiple respondents from Norway (3) and the UK (6). Views of technical capacity vary greatly across MS with Belgium, Finland and Germany having positive assessments and Italy and Spain having markedly low assessments. Regarding the feasibility of integrating ES values into national accounts by 2014, the widely held view is that this is not possible. The feasibility of achieving this goal by 2020, however, is considered to be achievable in half of the represented countries, with only Finland and Italy indicating a neutral position on feasibility.

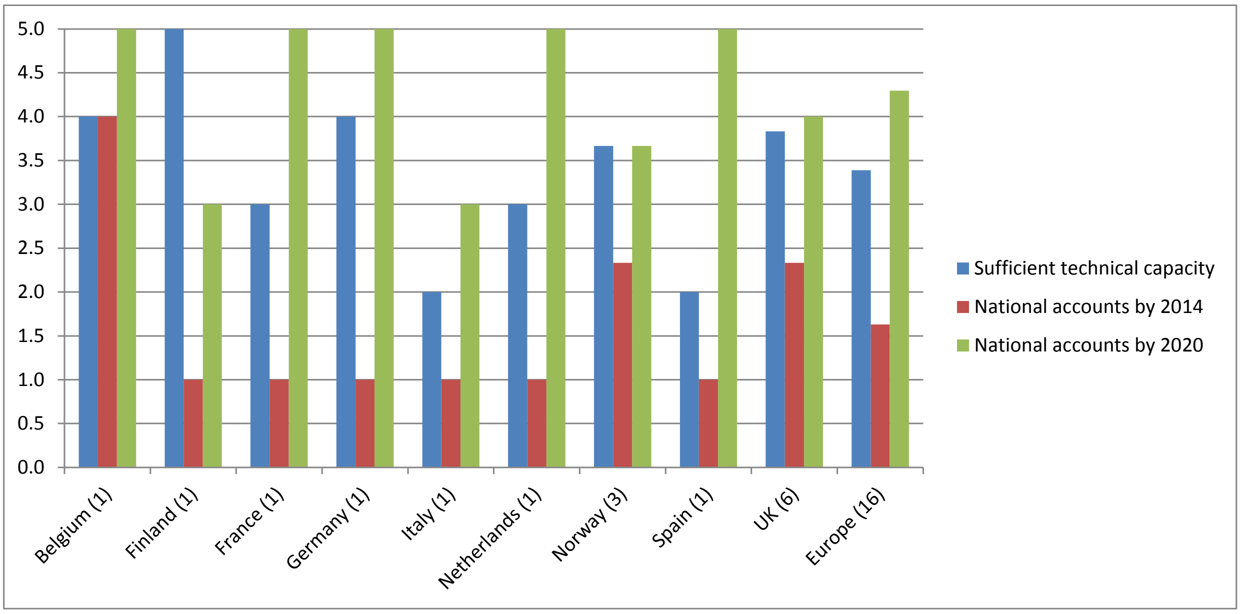

Figure 9. Expert opinions on technical capacity and feasibility of integrating ecosystem service values into national accounts (1 = don’t agree; 5 = completely agree)

6. Conclusions and recommendations

6.1 Conceptual framework and terminology

6.1.1. Introduction and terminology

The underlying objective of environmental valuation and accounting approaches is to support decision making in a manner which ensures that those decisions both improve wellbeing and ensure sustainable use of natural resources. To achieve this we first need to understand the linkage between those resources and the wellbeing they generate. A framework for shaping and clarifying that understanding is provided by the so-called 'ecosystem services' concept.

The Millennium Ecosystem Assessment (MA) defines ecosystem services as "the benefits people obtain from ecosystems" (MA, 2005; p.53). Fisher and Turner (2008) expand on this definition to propose that "ecosystem services are the aspects of ecosystems utilized (actively or passively) to produce human well-being" (p.2051). Both definitions clarify the anthropocentric focus of the ecosystem service concept. While a wider understanding of environmental processes may be a necessary part of any environmental accounting or valuation undertaking, it is the role of the natural world in delivering human wellbeing which is central to the ecosystem service concept. It is this human focus that necessitates the integration of economic analysis within such assessments so that we can quantify and value ecosystem services ensuring that their importance and worth can be incorporated within decision making.

The level of ecosystem services 'harvested' within any given period can be thought of as a 'flow' extracted from an underlying 'stock' of ecological assets (Barbier, 2009; Mäler *et al*. 2009)[3]. Just as with a stock of financial assets in a bank, the withdrawal rate can either be sustainable (say an amount which is less than or equal to the change in the real value of the financial asset in that period) or unsustainable (an amount which, if maintained, will eventually deplete the real value of the asset to a level which then reduces the available flow of income)[4]. For the moment we will assume that the rate of flow extraction is sustainable in that it does not deplete stocks. This reflects a 'strong sustainability' perspective on our engagement and dealings with the natural environment.

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[3] Having a larger *stock* of ecological assets might mean that more services will be enjoyed although, as Barbier *et al*. (2008) and Boyd and Krupnick (2009) note, the relationship may be non-linear and lagged.

[4] Note that economists will sometimes refer to flows as income and to stocks as wealth, the true intergenerational value of which is referred to as 'inclusive' or 'comprehensive' wealth (Arrow et al., 2007; Dasgupta, 2009; Mäler, 2008; Mäler et al., 2009).

We can now define a set of terms for subsequent use and which are intended to be generally understandable to the broad community involved in decision making, ranging from administrators, policy makers and the business community to specialist natural scientists and economists. The concept of ecosystem services and the terminology used to describe it has undergone (and is still undergoing) a process of development and refinement. As a consequence, different publications and initiatives use different concepts and terminology. Annex I presents a comparison of key terms and definitions as used by four current initiatives, namely the UK National Ecosystem Assessment (UK NEA), the European Environment Agency (EEA) Common International Classification of Ecosystem Services (CICES), the Mapping and Assessment of Ecosystems and their Services (MAES) working group, and the System of Environmental-Economic Accounting (SEEA) Experimental Ecosystem Accounts. The following definitions are based on those provided by these existing initiatives and attempt to be consistent with the MAES framework and CICES classification.

- 'Ecosystem services' are "the contributions that ecosystems make to human well-being". Ecosystem services are the last item in the chain of natural processes that provide inputs to the generation of products (defined subsequently) that are used by humans. Some ecosystem services are used as inputs in the production of manufactured products (e.g. trees used to make timber) whereas others are consumed directly (e.g. a natural area used for recreation).
- An important distinction is made between the underlying ecosystem processes (referred to in some terminologies as intermediate services, supporting services, ecosystem functions) and the ecosystem services that are used directly by humans (referred to in some terminologies as 'final ecosystem services'). The importance of this distinction is to avoid potential double counting when valuing and assessing ecosystem services. An analogy can be drawn from the production of any familiar yet complex product such as a car; if we add the value of the engine to that of the car then we overstate the total value of the good.
- 'Product' is the term for any object which generates human wellbeing. This includes both physical and non-physical (pure experiential, non-consumptive) objects; and embraces the economic definitions of both goods and services. So, while a piece of timber is a 'product' to the home improver; a beautiful natural landscape is a 'product' to the outdoor walker. These examples illustrate the diversity of products which derive at least in part from the natural environment. So while the use of timber is 'exclusive and its consumption rival' (only one person uses a given piece of timber and once used it cannot be fully re-used or consumed by somebody else), the landscape amenity is neither exclusive (multiple people can use the good) nor rival in consumption (at least to some extent, one person's use does not preclude another's). Some of these products come

straight from the natural world without the intervention of humans; the visual amenity of the natural landscape being an example of this (here the final ecosystem service and the product are identical). In contrast, other products (like our timber example) require some inputs of manufactured (e.g. machines) or other human capital.

- The term 'economic value' describes the change in human wellbeing (or welfare) generated by a product. The economic value of a product is the surplus or net economic gain resulting from its production and consumption. It comprises both the producer surplus and consumer surplus derived from a product.[5] In the case of ecosystem services that are consumed directly as products (e.g. visual amenity of a natural landscape, outdoor recreation), producer surplus is effectively zero and consumer surplus accounts of all of economic value. It should be noted that this welfare economic definition of value is different from the concept of 'exchange value' that is used and measured in the System of National Accounts (SNA). This distinction is explained in detail in section 6.2.3.2 and Annex 7.
- 'Ecological assets' are the stocks of ecosystems that have the potential to provide ecosystem services. In economic terms we can think of these as the 'wealth' of ecosystems. Ecological assets can be measured from two perspectives: 1. in terms of ecosystem conditions and extent; 2. in terms of ecosystem services provided. Ecological assets may also be described as a component of natural capital, the other component being abiotic resources. The concept of natural capital therefore encompasses all environmental resources, both biotic and abiotic components.

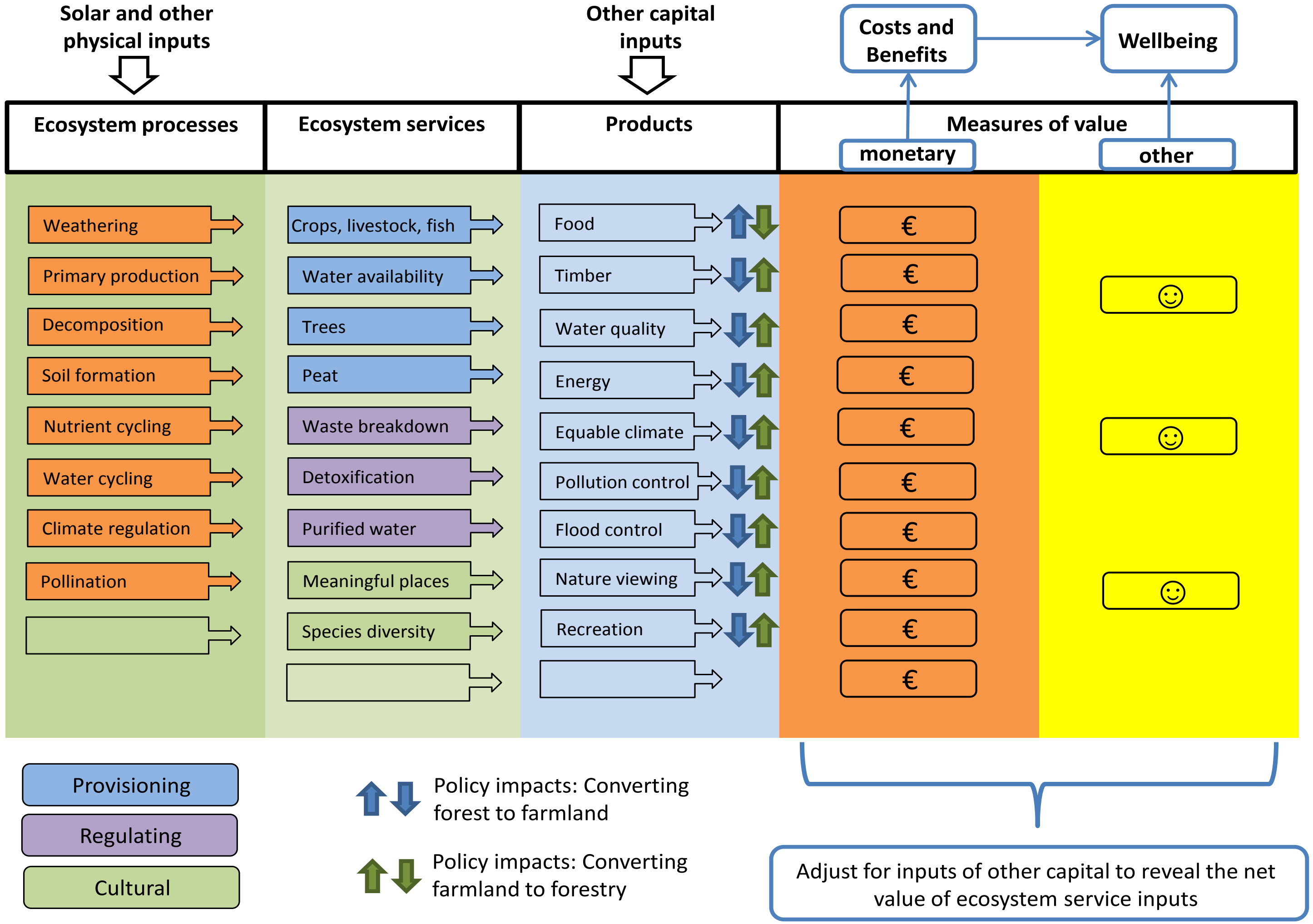
6.1.2. Conceptual framework

With these definitions in hand, we can now provide a schematic representation of the flow from natural processes through ecosystem services to the delivery of products and their value, as illustrated in Figure 10. As noted in the lower right hand corner of the figure, the value of any product cannot be fully attributed to ecosystem service inputs if in fact its production relies in part upon inputs of other capital. However, controlling for the latter allows us to calculate the value of the former (see UK NEA, 2011 for examples).

Figure 10 also illustrates the analysis of policy alternatives within the ecosystem service valuation approach. Two policies are considered; one positing the conversion of farm land into forestry and the other considering the opposite flow. The diversity and direction of impacts generated by these schemes is illustrated through the arrows placed in the 'products' column (green arrows for conversions from farming to forestry; blue for the conversions in the opposite direction). The main message of these illustrations is that a

[5] An explanation of the concepts of producer and consumer surplus is provided in Annex 7.

Figure 10: Conceptual framework for the economic assessment of policies incorporating ecosystem service flows
Adapted from Bateman et al., (2011), Mace et al., (2011) and UK NEA (2011).



NB the orange boxes under ecosystem processes are not named to avoid consistency issues with other frameworks. They are typically supporting, regulating, maintenance or 'underpinning' services. The empty boxes indicate that the lists do not necessarily cover all processes, services and products.

change which is often prompted by just a single product (e.g. an increase in food production) can generate multiple indirect impacts. Furthermore, consideration of those impacts shows that, while a minority have values reflected (often imperfectly) in market prices, many do not. Application of non-market valuation techniques is clearly vital if decisions are to capture the full diversity of values generated by these options. Failure to conduct such valuations is liable to result in incomplete assessments and poor decisions.

6.2 Applying the conceptual framework: choices

In applying the conceptual framework set out above to produce ecosystem service valuations and accounts, there are a number of choices to be made between alternative methods, approaches and classifications. In this section we outline these choices and describe, where possible and relevant, the strengths and weaknesses of each alternative option. Recommendations are presented in this way to allow Member States to choose the information and methods that are of highest relevance to them. We identify a multi-level 'decision tree', where decisions or choices at previous levels are highly correlated and/or drive decisions or choices at lower levels. In our outline, we try to identify the key issues involved at every stage or level. The 'decision tree' and the structure of the remainder of this section are visualized in Figure 11. We identify four main questions, starting with: what is the main objective of the valuation and accounting exercise. This choice drives the subsequent steps and choices in terms of their implications and appropriate valuation methods.

6.2.1. Choice level 1: What do you want to achieve?

It sounds like stating the obvious, but it cannot be emphasized enough that one has to carefully think through what one aims for when trying to assess, value and report ecosystem service values, and why. Economic valuations of the services provided by the natural environment and its resources generally tend to be used within one of two alternative frameworks:

(i) Appraisal of alternative projects, policies or investments, typically conducted using cost benefit analysis (CBA). The purpose of this framework is to support decision making by determining the economic desirability of an investment (in terms of net benefits) and providing a basis for selecting between alternative investments.

(ii) Environmental accounting. The purpose of this framework is to provide consistent information on the contribution of environmental resources to economic activity, growth and welfare. Such information is used for long-term management and empirical analysis of the macro-economy.

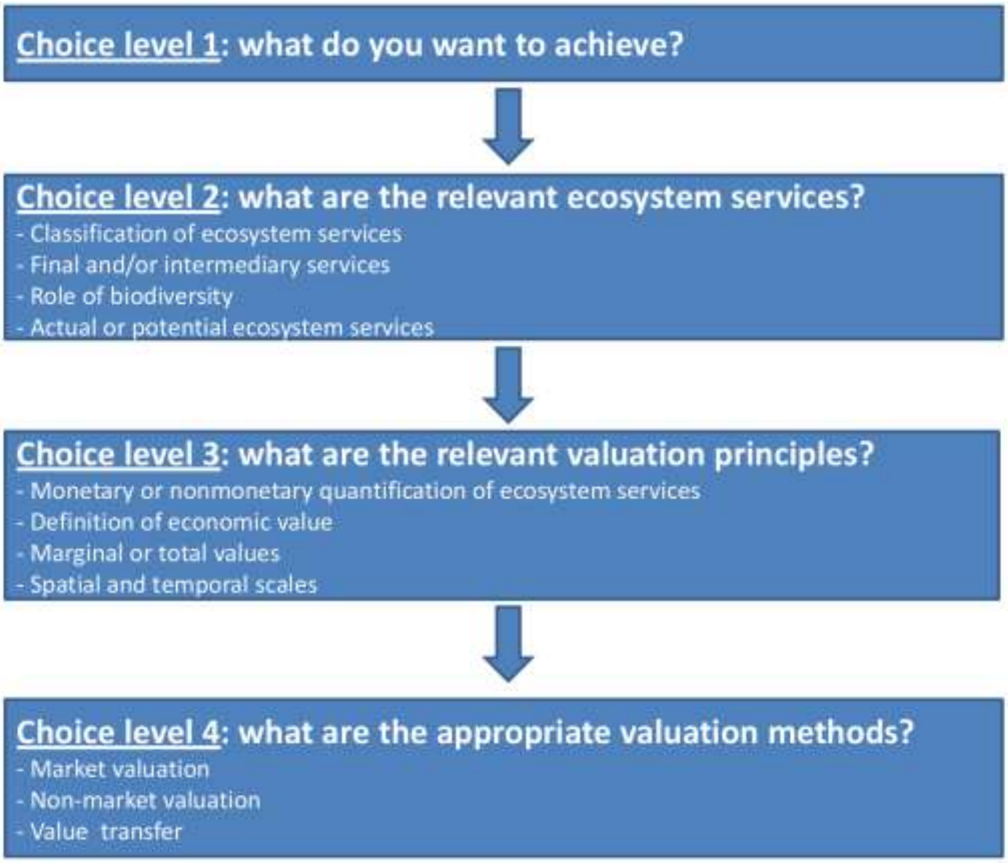


Figure 11: choice levels when deciding on ecosystem service valuation and accounting

Cost-benefit analysis and environmental accounting both involve valuations of environmental services but the treatment of values and the nature of the information produced is substantially different. Accordingly, the inputs, methods and precision required for each framework may be different.

This report is designed to provide guidance on the available options and choices for conducting environmental accounting, with the intention to support EU Member States in addressing Target 2, Action 5 of the EU Biodiversity Strategy:

"Member States, with the assistance of the Commission, will map and assess the state of ecosystems and their services in their national territory by 2014, assess the economic value of such services, and promote the integration of these values into accounting and reporting systems at EU and national level by 2020."

We interpret environmental accounting (also referred to as ecosystem accounting or reporting) in a broad sense to include both standardized accounting systems based on the System of National Accounts (SNA) compiled in statistical offices in European Member

States and more flexible reporting formats compiled outside globally standardized accounting frameworks such as the SNA.

6.2.2. Choice level 2: What are the relevant ecosystem services?

6.2.2.1 Classification and categorization of ecosystem services

A review of various ecosystem assessments and frameworks, including the MA, UK-NEA, TEEB and CICES, shows a considerable degree of variation in the remit of analysis, most particularly in respect of the ecosystem services considered.

A useful exercise for future applications would be to establish such a fully comprehensive list of the services provided by the natural environment so as to provide a common baseline for all future assessments. However, we recognise that such a list is likely to be both extensive and to go considerably beyond the remit of available prior empirical data and information. While Member States should strive towards assessments of all relevant services, practical guidelines should be drawn up for prioritisation of service analyses. These should consider two main principles:

- *Resource availability:* This includes not only financial resources, but also the time available for assessments, the availability of data and the available knowledge and expertise;
- *Local priorities:* The geographical land use diversity across the EU means that ecosystem services vary substantially across Member States, resulting in differing sets of related goods and values, alongside differing challenges in their assessment, mapping and reporting.

By comparing proposed priorities for assessments with a more comprehensive list, third party assessors have a readily available starting point for evaluating the local priorities and how these might be common or differ across EU Member States and the quality of the (proposed) assessments within Member States.

Classifications of ecosystem services: strengths and weaknesses

	Strengths	Weaknesses
MA	Defined ecosystem services for first time High policy impact	Inconsistent with SNA approach No distinction between intermediate and final delivery of services
TEEB	Avoids risk of double counting by focusing on final services Habitat services included as separate category	No intermediate services Inconsistent with SNA approach
CICES	Consistency with SNA Complementary tables for abiotic outputs can be developed Avoids risk of double counting by distinguishing clearly between intermediate and final services as in SNA	Aims to be comprehensive, hence there is most probably a need for more detailed prioritization of relevant ecosystem services across EU Member States

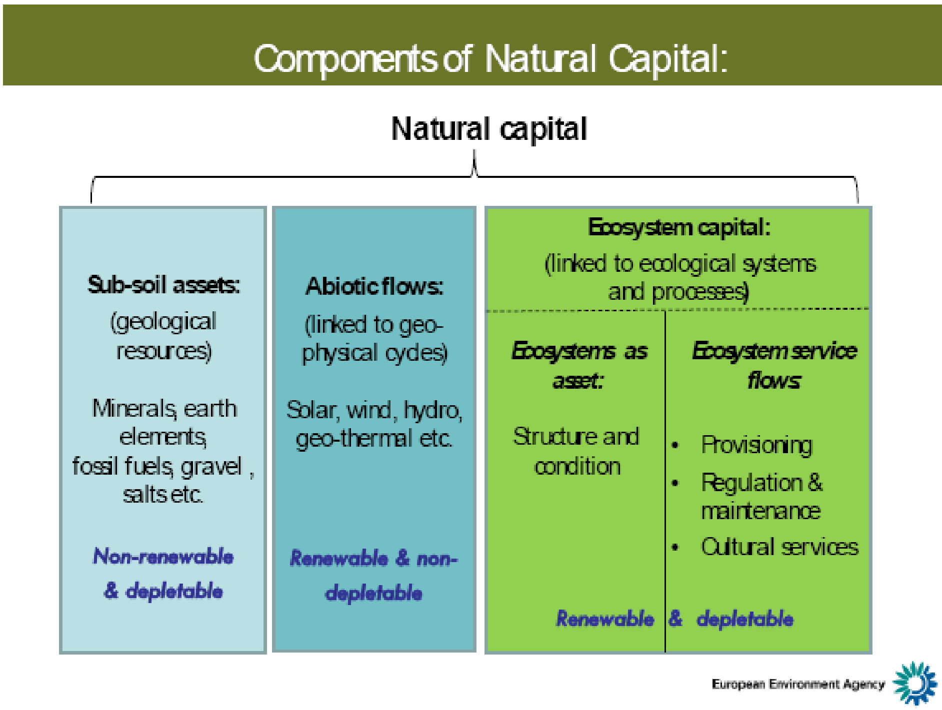
6.2.2.2 Inclusion of abiotic resources

Most existing ecosystem assessments, including the MA, TEEB and UK-NEA, have focussed principally upon biotic ecosystem services. In some future applications, however, it may also be of direct policy relevance to include abiotic resources provided by the natural environment that generate wellbeing, i.e. to conduct a comprehensive assessment of all services and resources generated and provided by natural capital that covers both biotic (ecosystem) and abiotic resources. Such an assessment would enable the examination of trade-offs between all forms of natural capital and their associated services and resources.

The exclusion of abiotic resources from assessments of the natural environment has the disadvantage of omitting potentially important economic impacts and ignores the trade-offs that may exist between biotic ecosystem services and abiotic resources such as valuable minerals. A decision system that aims at sustainable resource use should ideally consider all of the services and resources provided by the natural environment, both biotic and abiotic. To some extent abiotic resources, such as those provided by minerals, wind, and geothermal heat, are already implicitly included in economic accounts as inputs to production processes. Others, such as a stable climate, may not be fully accounted for. In either case, the explicit valuation and accounting of these resources enables their management and inclusion in decision making.

A further reason for including both ecosystem services and abiotic resources in the broader classification and assessment of resources and services from natural capital is that the distinction between the two is not always straightforward. For example, water is an abiotic mineral resource used for nutrition and as a material, but it is also a fundamental part of many ecosystem processes. Ecosystems in turn play an important role in determining the quantity and quality of water. For this reason, the CICES classification includes water as an ecosystem service and provides scope for a complementary classification of abiotic resources. From an economic perspective the frameworks for valuing and accounting for ecosystem services and abiotic resources are compatible and broadly the same.

Several important distinctions can be drawn between different types of natural capital and associated services that have implications for the management of those resources (e.g. distinctions between renewable/non-renewable, consumptive/non-consumptive). These characteristics, however, are not exclusive to ecosystem services or abiotic resources and so do not provide a basis for exclusion of abiotic resources from the assessment framework (see also the graph below).



Source: European Union (2013). Mapping and assessment of ecosystems and services. An analytical framework for ecosystem assessments under Action 5 of the EU Biodiversity Strategy to 2020. Discussion paper. Publications office of the European Union, Luxembourg.

Nevertheless, it may be argued that classifications and assessments of services from natural capital should make a distinction between ecosystem services and abiotic resources in order to focus attention on the specific threats, complexities, uncertainty, thresholds, role of biodiversity, and the often limited substitutability that characterise ecosystem services and abiotic resources.

Inclusion of abiotic resources in the assessment framework: strengths and weaknesses

	Strengths	Weaknesses
Exclusion of abiotic resources	Focus on the specific threats, complexities, thresholds, biodiversity and limited potential substitutability that characterize ecosystem services Ensures a clear focus on ecosystem services	Lacks a comprehensive assessment of all services and resources provided by natural capital Limits the assessment of trade-offs between ecosystem services and abiotic resources
Inclusion of abiotic resources	Provides a comprehensive assessment of all services provided by natural capital Enables a direct assessment of trade-offs between ecosystem services and abiotic resources	Diverts attention from the specific complexities associated with ecosystem services Some abiotic resources are already included in national accounts or satellite accounts as inputs in production. Need to avoid double counting

6.2.2.3 The role of biodiversity in the ecosystem service framework

The role of biodiversity remains ill-defined in all the existing ecosystem service classifications. From a historical perspective, several decades of unresolved academic debate about biodiversity valuation (e.g. Simpson, 2007) has now shifted away from valuing biodiversity per se to the valuation of ecosystem services. As described by Mace et al. (2012), biodiversity plays multiple roles within the ecosystem services framework:

- As an intermediate service (e.g. enhancing soil fertility; enhancing ecosystem resilience to stabilise and maintain the flow of other services)
- As a final ecosystem service (e.g. enhancing the rate of pollination of food crops)
- As a good generating a use value (e.g. as above but also when nature watchers gain utility from viewing a wider diversity of species)
- As a good generating non-use or existence value (e.g. when an individual gains utility simply from the knowledge that some species will continue to exist).

This recognition of the multiple roles of biodiversity leaves a choice of whether to include biodiversity in the ES framework as a final ES, and if so in which measurement units (physical or monetary). Economic valuation of biodiversity is not without difficulties and problems. Little guidance exists as to how to do this “best”. Several attempts have been made to provide guidelines for economic valuation of biodiversity (e.g. OECD, 2002), but economic valuation of biodiversity has received quite a bit of criticism (e.g. Nunes and van den Bergh, 2001; Spangenberg and Settele, 2010). An important hurdle remains the estimation of the so-called existence values of biodiversity with the help of stated preference methods and public surveys. It is also not always clear what the public at large really understands of the multi-faceted concept of biodiversity. Moreover, scientific understanding of the option or insurance value of biodiversity, or the role of biodiversity in the provision of different ecosystem services, remains also unclear. This latter relationship between ecosystem services and biodiversity at larger scale has hardly been systematically investigated so far in science (e.g. Reiss et al., 2009; Isbell et al., 2011). The way forward here seems to be to assess more systematically the role of biodiversity as an input factor in bio-economic models.

An alternative approach would be to consider biodiversity as critical natural capital in view of the rate at which biodiversity vanishes from the planet (e.g. Röckstrom et al., 2009). Critical natural capital is closely related to the concept of strong sustainability, meaning that there are limits to the extent to which natural capital and the services they provide can be replaced by human made capital and human ingenuity. Without this critical stock of capital, life on earth as we know it would be impossible. By labelling biodiversity as critical natural capital (based on the precautionary principle or safe minimum standards), trade-offs are not possible anymore, and hence their valuation becomes futile. This does not mean that they cannot be subject to measurement and economic analysis: it will still be relevant to know how much biodiversity there is and how to conserve biodiversity in the most cost-effective manner possible. But the biodiversity itself is not a tradable "service" or "product" anymore.

6.2.2.4 Valuation of final and intermediate goods and services

The distinction between final and intermediate ecosystem services is made in the earlier section setting out the conceptual framework. To recap briefly here: 'final ecosystem services' are the last link in the chain of natural processes that contribute to human wellbeing by inputting to the production of goods. 'Intermediate ecosystem services' are natural processes that contribute to other ecosystem functions, but do not directly input into the production of goods consumed by humans.

Fisher et al., (2008) argue that economic analyses should focus on 'final ecosystem services' in order to avoid potential double counting of ecosystem service values. The valuation of intermediate ES may highlight the importance of individual component ecosystem functions within the chain natural processes contributing to the production of a good, but should not be aggregated for inclusion in accounts.

Valuation of final and intermediate goods and services: strengths and weaknesses

	Strengths	Weaknesses
Valuing only final ES	Avoids potential double counting	Intermediate (supporting) services not explicitly valued
Valuing final and intermediate ES	More comprehensive understanding of the role and value of component ecosystem functions	Potential double counting of ES values

6.2.2.5 Valuation of stocks and flows

Many if not most existing frameworks for environmental accounting look at making an extension to capital accounting, i.e. make adjustments to the value of assets by including the value of environmental assets and their depreciation, whereas most ecosystem service valuation studies estimate the value of (changes in) flows of ecosystem services. It should be possible to convert information on the values of flows to the value of assets (capitalised flows), but this is a step away from the information that is generally available. An alternative option is to extend the current accounts by including the values of the flow of ecosystem services, i.e., make adjustments to the value of national income based on the associated flows of ecosystem services.

The UK NEA makes the following distinction between valuation of stocks and flows: valuation of stocks incorporates the assessment of sustainability of use/depletion/ degradation over time, whereas the valuation of flows mostly does not. Arguably, the focus on flows rather than stocks is perfectly acceptable provided that we are operating safely above any thresholds below which natural capital stocks (and hence the sustainability of flows) might collapse (including thresholds set based on precautionary principles and safe minimum standards).[6]. However, there is in many cases still a lack of data on and understanding of threshold levels for different ecosystem stocks.

[6] Note that the use of flow values for the depletion of stocks is also fundamental to sustainability analyses based on both renewable and non-renewable resources in economic growth modeling (see, for example, Dasgupta, 2009; Hamilton and Ruta, 2009; and Mäler, et al., 2009).

Valuation of flows and stocks: strengths and weaknesses

	Strengths	**Weaknesses**
Valuation of flows	Provides information on trends in provision and use of ES	Doesn't provide information on the impact of use on the underlying ecosystem stock
Valuation of stocks	Provides information on the impact of use on the underlying ecosystem stock	Difficult to assess due to limited scientific understanding of relationships between provision of ES and ecosystem stocks

6.2.2.6 Actual, expected and potential ecosystem services

It is recommended that valuation and accounting focuses only on ecosystem services that actually provide inputs to the production of goods that are consumed, as opposed to valuing potential ecosystem services. The concept of 'potential ecosystem services' relates to the capacity of ecosystems to supply ecosystem services without reference to any current or future demand for those services.

The modelling and valuation of potential ecosystem services highlights the capacity of ecosystems to supply as yet unknown future demand for ecosystem services, but is likely to lead to exaggerated estimates of ecosystem service values and does not provide useful information for policy making, i.e. the value information bears no relation to the actual benefits realised from ecosystems due to the fundamental uncertainty involved. The valuation of future flows of ecosystem services needs to be based on scenarios that incorporate descriptions of both supply and demand as determinants of future ecosystem service provision. As such, scenarios of the future provision of ecosystem services should focus on describing future *expected* flows rather than future *potential* flows.

Actual and potential ecosystem services: strengths and weaknesses

	Strengths	**Weaknesses**
Value actual ES	Provides information on the actual level of use of ES	May under-estimate potential future use of ES
Value potential ES	Recognises the capacity of ecosystems to supply as yet unknown future demand for ES	Does not make a link between provision and demand for ES. Likely to overstate values

6.2.3. Choice level 3: What are the relevant valuation principles?

6.2.3.1 Quantification of ecosystem services in monetary terms[7]

A further decision to be taken in the implementation of ecosystem service assessments and accompanying economic valuation and accounting concerns the decision regarding whether values should be assessed in monetary or non-monetary terms. For the reasons set out in the conceptual framework, commensurate valuation is clearly preferable if this can be conducted in a reliable and robust manner. How then should we assess such robustness? Two issues are pertinent here: bias and variance (with the latter, for simplicity, being referred to as uncertainty).

The literature on the economic valuation of non-market natural environment services is extensive and replete with assessments of potential bias within derived estimates. However, a critical view of this literature highlights the fact that many of these bias tests are internal rather than external (i.e. they simply assess whether values are consistent with other values derived from the same study rather than comparing with some exogenous 'criterion' measure). This tendency is understandable given that such studies are typically examining goods for which there is no external measure (e.g. no available market price). Furthermore, those few studies that do attempt such external testing often (although not always) assess results by comparing them to expectations derived from standard economic theory with the inference being that market prices pass such tests. Unfortunately there is considerable evidence that this latter assertion does not hold. Market prices are rarely the clean product of perfectly operating competitive markets interacting with perfectly informed consumers and producers (as standard economic theory assumes[8]).

Given this somewhat messy real world situation, the requirement that non-market valuations of environmental goods should conform perfectly to a simple interpretation of economic theory – when it is clear that many market prices do not – seems unreasonable. The rule instead should be that non-market valuations should be no more distorted than market prices.

More generally decision makers need to be aware that, just as per market prices, non-market values are responsive to certain contextual factors. The impact of spatial context is

[7] We only focus on monetary valuation here as this was the specific scope of the assignment (and non-monetary valuation fell outside the scope of the project). We acknowledge the need to closely link this to (spatially explicit) biophysical accounting and indicator frameworks, where necessary and possible in Geographical Information Systems (GIS). This includes, for example, existing national guidelines on resource and habitat restoration using equivalency methods in the context of the EU Environmental Liability Directive.

[8] Note that this characterisation is, some would argue, rather harsh as there has been great advances in economic theory in recent years – most notably through its blending with the behavioural and psychological sciences to yield a more robust (if less pleasingly simple) set of theories and empirical predictions.

discussed below. In addition, values can change over time as the characteristics of the population change and can also vary through the introduction of new substitutes or complements. These valuations reflect the complexities not only of the ecosystem services from which derived products are obtained, but also the complexities of the people whose preferences they reflect.

In cases where it is not possible to produce sufficiently robust value estimates, we have to accept that for some ecosystem services and contexts it is not possible to estimate monetary values for the associated welfare and describe effects in other units or qualitatively.

6.2.3.2 Definition of economic value

There is an important choice to be made regarding the measure of economic value that is used in the valuation and accounting of ecosystem services. The economic value of a product is, as mentioned, a measure of its contribution to human welfare. Most economic analyses of ecosystem services attempt to provide estimates of changes in theoretically valid definitions of welfare (e.g. consumer or producer surplus) resulting from changes in the provision of ecosystem services.

The system of national accounts (SNA), on the other hand, measures the total value of income, production and expenditure as evidenced by transactions. This is the measurement of 'exchange value' and conceptually corresponds to market prices multiplied by quantities (see Annex 7 for an explanation of the differences between welfare economic and exchange concepts of value). In practice, national accounts are computed by summing transactions as evidenced on invoices etc. This utilises relatively easily obtained data and allows the SNA to be applied consistently across countries and time periods, but it does not correspond to a theoretically valid measure of welfare. The exchange concept of value in the SNA does not provide information on the resulting improvement in welfare for either the seller (producer) or purchaser (consumer) in the transaction.

To incorporate ES values into national accounting, the choice is therefore between using (1) theoretically correct measures of the welfare derived from ecosystem services, for which some value data is available from primary valuation studies but which are inconsistent with the values used by the national accounts; (2) theoretically invalid measures of welfare that are consistent with SNA, but for which limited data is available.

The statement of this choice is perhaps overly simplified given that to some extent it is possible to convert different value concepts into each other, e.g. simulated exchange value methods approximate market values through a simulated market. Furthermore, for some ecosystem services market prices exist.

Definitions of economic value: strengths and weaknesses

	Strengths	Weaknesses
Theoretically correct measures of welfare	Valid measure of welfare. Some value data is available for ES	Inconsistent with SNA approach
Approximate welfare using information on the exchange value of transactions	Consistency with SNA	Limited data available for most ecosystem services

6.2.3.3 Marginal and total valuations of ecosystem services

An important aspect of welfare analyses is the need to consider how the unit value of a given product (known by economists as the 'marginal value' of that product) might change as the provision of the product also alters. This is especially relevant for the accounting of ecosystem services for which marginal values might change significantly as the level of provision changes.

Computing total economic value of ecosystem services, or total exchange value as in the SNA, is arguably not useful, but also not advisable for several reasons. For ecosystem service assessments, it is argued that total valuations of the flow of ecosystem services is nonsensical and that ecosystem service assessments should only consider marginal changes in value and not total values:

1. The unit values (prices) for ecosystem services that are either observed in markets or estimated through non-market valuation methods are marginal values, which reflect the value of an additional unit at the existing level of provision. It is generally the case that marginal values are not constant across the entire stock of a resource/quantity of a service (i.e. marginal values will increase with scarcity). Multiplying the quantity of an ecosystem service by its marginal value can therefore lead to an over- or under-estimation of total value.
2. In some cases ecosystem services are fundamental to human wellbeing. In such cases the total values of these services are argued to be infinite.
3. Generally most policy decisions will result in relatively small or marginal changes to the level of ecosystem service provision. Very rarely will a policy decision consider the total loss of an ecosystem service. It is therefore more useful to provide information on the value of smaller changes in ecosystem service provision.

Marginal and total valuations of ecosystem service values: strengths and weaknesses

	Strengths	Weaknesses
Valuation of marginal changes in the provision of ecosystem services	Relevant to decision making on environmental policy	Not directly compatible with SNA income measures
Valuation of total provision of ecosystem services	Comparable with GDP	Theoretically questionable. Does not account for non-constant marginal values and thresholds

6.2.3.4 Spatial variability in ecosystem service values

The value of an ecosystem service is, as with the value of any economic good or service, determined by its supply and demand. It is not possible to determine the value of ecosystem services through assessment of only supply or only demand. The determinants of both the supply side (ecosystem functioning) and the demand side (use, preferences and characteristics of beneficiaries) of ecosystem services are highly spatially variable.

Spatial factors that affect the supply of ecosystem services include: ecosystem area (possibly characterised by a non-linear relationship and/or with thresholds), networks, fragmentation, quality (e.g. biodiversity hotspots), and the scale of delivery (e.g. local, national, global scales). Spatial factors that affect demand for ecosystem services include: the number of beneficiaries, distance to the ecosystem, availability of substitutes, complements, and accessibility. See Bateman et al. (2006) and Hein et al. (2006) for discussions of spatial determinants of ecosystem service demand and supply.

Accounting for spatial variability in ecosystem service values requires a closer integration of the biophysical assessment and mapping of ecosystem services into the valuation of ecosystem services. The disconnection between these steps in the ecosystem service assessment-valuation-accounting process persists. The valuation of ecosystem services requires a strong collaboration of scientists and economists and cannot be left entirely to one discipline (scientists, economists or statisticians). This requirement is likely to have consequences for the institutional design for incorporating ecosystem service values into national reporting, i.e. it requires an institution that houses multiple disciplines.

Accounting for spatial variability in demand and supply for ecosystem services: strengths and weaknesses

	Strengths	**Weaknesses**
Valuation with no spatial variation in supply or demand for ES	Simple. Available data	Ignores spatial variability in values of ES
Valuation with spatial variation in supply and no spatial variation in demand for ES	Accounts for spatial variation in the provision of ES	Ignores spatial variability in values due to variation in demand
Valuation with spatial variation in demand and no spatial variation in supply for ES	Accounts for spatial variation in the demand for ES	Ignores spatial variability in values due to variation in supply
Valuation with spatial variation in both supply and demand for ES	Accounts for spatial variation in the supply and demand for ES	Data intensive and analytically complex

6.2.4. Choice level 4: What are appropriate valuation methods?

Here, again a number of choices have to be made: whether or not to carry out an original valuation study or to collect and use existing values, either from secondary market data sources or existing (incidental) non-market valuation studies, also referred to as value transfer. Within both approaches, a number of possible methods exist from which can be chosen.

6.2.4.1 Primary valuation or value transfer

Primary valuation involves estimating the value of ecosystem services through the collection of data that is specific to the ecosystem(s), service(s) and beneficiaries that are under consideration.

Value transfer, by contrast, involves estimating the value of ecosystem services through the use of value data and information from other similar ecosystems and populations of beneficiaries. It involves transferring the results of primary valuations for other ecosystems ("study sites") to ecosystems that are of current policy interest ("policy sites"). Reliable value transfer is dependent on the availability of reliable primary valuation results. It is not a perfect substitute for primary valuation. As the number and breadth of reliable primary valuations increases, the scope for reliable value transfer also increases. Ecosystem service values estimated using value transfer may be characterised by high uncertainty. For this reason it is preferable to conduct primary valuations of ecosystem services, if resources (data, time, expertise, knowledge) are available.

In cases where it is not possible to produce sufficiently robust value estimates, either through primary valuation or value transfer, we have to accept that for some ecosystem services and contexts it is not possible to estimate monetary values for the associated welfare.

Primary valuation and value transfer: strengths and weaknesses

	Approach	Strengths	Weaknesses
Primary valuation	Collect site specific data on ES and preferences of beneficiaries	Provides context and case specific information on ES values	Can be expensive, time consuming and technically complex to implement; Generally applied at local/ecosystem scales
Value transfer	Transfer existing value information for other ecosystems ("study sites") to ecosystems that are of current policy interest ("policy sites")	Lower cost and less time consuming than primary valuation; Enables scaling-up values across larger geographic scales; Consistency in the estimation of values across policy sites	Possible low accuracy of value estimates; Can be as data intensive and technically difficult as primary valuation.

6.2.4.2 Selection of appropriate primary valuation methods

Economists have developed a variety of methods for estimating the value of goods whose market prices are either imperfect reflections of that value or non-existent. These methods are designed to span the range of valuation challenges raised by the application of economic analyses to the complexity of the natural environment. Application guidelines are available in detail in a number of existing reviews.[9] The selection of appropriate valuation method is in part determined by the type of ecosystem service being valued. Table 3 indicates which primary valuation methods can be used to value each ecosystem service.

An overview of primary valuation methods, typical applications, and limitations are summarised in Table 4. More detailed discussions of market prices and replacement/ restoration costs as measures of ecosystem service values are provided in the following two paragraphs since these approaches have received particular attention and recommendation in existing guidelines on ecosystem service accounting.

[9] See, for example, Barbier (2007), Bateman et al., (2002), Champ et al., (2003); Freeman (2003), Hanley and Barbier (2009), Heal et al. (2005), Kanninen (2006) and Pagiola et al. (2004)

The market price of a good is simply that portion of its value which is realised within the market place. In some cases price may be an acceptable approximation of marginal welfare value, particularly where all the inputs to the production of a good are privately owned, the good is produced in a competitive market[10] and where there is not large scale intervention by governments or other authorities.[11] Indeed even when these latter distortions do arise economists can often adjust for their influence. Market prices, however, can in some cases be a poor approximation of value or be completely missing. The divergence between market price and marginal welfare value can often be substantial and is a characteristic of many of the goods produced by the natural environment.

Replacement/restoration cost is widely used as a measure of ecosystem service value. Estimations of cost, however, are generally not good proxies for benefits. The underlying assumption for this valuation method, which may not always be valid, is that the benefits are at least as great as the costs involved in replacing or restoring an ecosystem service. The replacement/restoration cost method will tend to over-estimate ecosystem service values if society is not prepared to pay for man-made replacements (i.e. if there is insufficient demand). Alternatively, in the case that society is prepared to pay for the man-made replacement, the cost of replacement provides only a lower bound estimate of the benefit (i.e. we only know that the benefits of restoration exceed the cost). The use of cost based methods for estimating ecosystem service values may therefore produce information that is not useful for decision making. For example, the EU Water Framework Directive art. 4 states that derogations from attaining the objective of “good ecological status” in water bodies can only be given if costs of measures are disproportionate. From an economic point of view, disproportionality is interpreted to mean a situation in which costs exceed benefits by a considerable margin. So measuring the benefits of a policy measure in terms of the costs and then comparing them also to the costs would lead to ill informed decision making. The UK NEA excludes the use of restoration or replacement costs as a proxy for the value of ecosystem services. Many economists consider that such methods should be used with caution (Barbier 1994 and 2007; Ellis and Fisher 1987; Freeman 2003; Heal, 2000) due to the suspicion that restoration or replacement costs may bear little resemblance to the values they approximate.[12]

[10] Typically, the less competitive a market the more any individual producer can exert pressure upon price.

[11] Interventions such as government subsidies or taxation can distort prices from their competitive market levels.

[12] Note that information on costs is still useful in decision making (e.g. CBA, CEA) but it is not a reliable measure of benefits.

Table 3 Ecosystem services and applicable valuation methods

Services	Valuation Methods	Comments on Valuation Methods
Provisioning		
Crops/timber		Most ecosystem services of agro-ecosystems will be capitalized in land prices. They should be adjusted for specific capital investments, such as for irrigation and drainage. Bio-economic modeling (production function method) can be used to estimate the value added of the provisioning service vis-à-vis other necessary input factors.
Livestock		
Wild foods		The market price of a close-substitute food or fuel might be a fair proxy. The cost of production should be subtracted.
Wood fuel		
Capture fisheries		The production function method is preferred, see Barbier (2007). Otherwise (adjusted) market prices can be used as a rough proxy, but the cost of other inputs to production should be subtracted.
Aquaculture		
Genetic		Appropriate market prices are for example license fees for prospecting. An alternative valuation method is based on the costs of alternatives approaches to recover genetic information.
Fresh water		Market prices (if available), shadow prices (through production function method).
Regulating		
Pollination		Bio-economic modeling, accounting for the other input factors, including pollination is recommended. Alternatively, expenditures for alternative pollination technologies (replacement cost) might be used.
Climate regulation		The preferred cost-based method is 'damage cost avoided'
Pest regulation		Expenditure on manufactured pest regulation products (replacement cost) might be used
Erosion regulation		The preferred cost-based method is 'damage cost avoided', i.e. the loss in revenues as a result of soil erosion.
Water regulation		Avoided expected damage costs of floods and droughts; revealed or stated preference methods might be used to estimate the willingness to pay to avoid these expected damages
Water purification		Replacement cost might be used (see e.g. Chichilnisky and Heal, 1989), i.e. the costs of water purification by (often) public utilities or private drinking water companies.
Hazard regulation		Avoided expected damage cost; revealed or stated preference methods might be used to estimate the willingness to pay to avoid these expected damages (accounting for risk aversion).
Cultural		
Recreation		Methods include travel cost methods, contingent valuation, choice experiments
Aesthetic		Methods include hedonic price methods, contingent valuation, choice experiments
	Market price based methods ((adjusted) market prices, net factor income,)	
	Production function methods	
	Cost-based methods	
	Revealed preference methods (travel cost method, hedonic price methods)	
	Stated preference methods (contingent valuation, choice experiments)	

Table 4 Primary valuation methods, typical applications, examples and limitations

Valuation method	Approach	Applications	Example ecosystem service	Limitations
Market prices	Use prices directly observed in markets	ES that are traded directly in markets	Timber and fuel wood from forests; clean water from wetlands	Market prices can be distorted e.g. by subsidies. Most ES not traded in markets
Public pricing	Use public expenditure or monetary incentives (taxes/subsidies) for ES as indicator of value	ES for which there are public expenditures	Watershed protection to provide drinking water; Purchase of land for protected area	No direct link to preferences of beneficiaries
Replacement cost	Estimate cost of replacing ES with man-made service	ES that have a man-made equivalent that could be used and provides similar benefits to the environmental service.	Coastal protection by dunes; water storage and filtration by wetlands	No direct relation to ES benefits. Over-estimates value if society is not prepared to pay for man-made replacement. Under-estimates value if man-made replacement does not provide all of the benefits of the original ecosystem.

Valuation method	Approach	Applications	Example ecosystem service	Limitations
Restoration cost	Estimate cost of restoring degraded ecosystems to ensure provision of ES	Any ES that can be provided by restored ecosystems	Coastal protection by dunes; water storage and filtration by wetlands	No direct relation to ES benefits. Over-estimates value if society is not prepared to pay for restoration. Under-estimates value if restoration does not provide all of the benefits of the original ecosystem.
Damage cost avoided	Estimate damage avoided due to ecosystem service	Ecosystems that provide storm or flood protection to houses or other assets	Coastal protection by dunes; river flow control by wetlands	Difficult to relate damage levels to ecosystem quality.
Net factor income	Revenue from sales of environment-related good minus cost of other inputs	Ecosystems that provide an input in the production of a marketed good	Filtration of water by wetlands; commercial fisheries supported by coastal wetlands	Tendency to over-estimate values since method attributes all normal profit to the ES
Production function	Estimate value of ES as input in production of marketed good	Ecosystems that provide an input in the production of a marketed good	Soil quality or water quality as an input to agricultural production	Technically difficult. High data requirements
Hedonic pricing	Estimate influence of environmental characteristics on price of marketed goods	Environmental characteristics that vary across goods (usually houses)	Urban open space; air quality	Technically difficult. High data requirements

Valuation method	Approach	Applications	Example ecosystem service	Limitations
Travel cost	Use data on travel costs and visit rates to estimate demand for recreation sites	Recreation sites	Outdoor open access recreation	Technically difficult. High data requirements
Contingent valuation	Ask people to state their willingness to pay for an ES through surveys	All ecosystem services	Species loss; natural areas; air quality; water quality landscape aesthetics	Expensive and technically difficult to implement. Prone to biases in design and analysis
Choice modelling	Ask people to make trade-offs between ES and other goods to elicit willingness to pay	All ecosystem services	Species loss; natural areas; air quality; water quality; landscape aesthetics	Expensive and technically difficult to implement. Prone to biases in design and analysis
Group valuation	Ask groups of stakeholders to state their willingness to pay for an ES through group discussion	All ecosystem services	Species loss; natural areas; air quality; water quality; landscape aesthetics	Prone to biases due to group dynamics

6.2.4.3 Selection of appropriate value transfer methods

Primary valuation research is time and money intensive and results are still limited for many locations and ecosystem services. For this reason there is interest in transferring values from existing primary valuation studies to other ecosystem sites that are of policy interest. Value (or benefit) transfer is the procedure of estimating the value of an ES of current policy interest (at a "policy site") by assigning an existing valuation estimate for a similar ecosystem (at a "study site"). Guidelines for the application of value transfer are discussed in detail in a number of reviews.[13] Value transfer can potentially be used to estimate values for any ecosystem service, provided that there are primary valuations of that ecosystem service from which to transfer values. Value transfer methods have been employed in most national ecosystem assessments that include valuation (e.g. the UK NEA, 2011; EEA, 2010).

Value transfer methods can be divided into three categories: unit value transfer (with or without adjustments; usually for differences in income and price levels); value function transfer (using an estimated value function from an individual primary study); and meta-analytic function transfer (using a value function estimated from the results of multiple primary studies).

For a number of reasons the application of value transfer methods may result in significant transfer errors, i.e. transferred values may differ significantly from the actual value of the ecosystem service under consideration. There are three general sources of error in the values estimated using value transfer: 1. Errors associated with estimating values at the study site(s). Measurement error in primary valuation estimates may result from weak methodologies, unreliable data, analyst errors, and the whole gamut of biases and inaccuracies associated with valuation methods; 2. Errors arising from the transfer of study site values to the policy site. So-called generalisation error occurs when values for study sites are transferred to policy sites that are different without fully accounting for those differences. Such differences may be in terms of population characteristics (income, culture, demographics, education etc.) or environmental/physical characteristics (quantity and/or quality of the ecosystem service, availability of substitutes, accessibility etc.). There may also be a temporal source of generalisation error since preferences and values for ecosystem services may not remain constant over time; 3. Study selection bias may result in an unrepresentative stock of knowledge on ecosystem service values. The processes through which study sites are selected and results are disseminated may be biased towards certain locations, services, methods and findings, which results in an available stock of knowledge

[13] See for example Navrud and Ready (2007).

that is not representative of the resource under consideration and does not meet the information needs of value transfer practitioners.[14]

Value transfer methods: strengths and weaknesses

	Approach	Strengths	Weaknesses
Unit values	Select appropriate values from existing primary valuation studies for similar ecosystems and socio-economic contexts	Simple	Does not account for context specific variation in ES values. Value information for highly similar sites is rarely available
Adjusted unit values	Adjust unit values to reflect differences between study and policy sites (usually for income and price levels)	Simple. Adjusts for some differences in income, price levels etc.	Unlikely to be able to account for all factors that determine differences in values between study and policy sites
Value function transfer	Use a value function derived from a primary valuation study to estimate ES values at policy site(s)	Allows differences between study and policy sites to be controlled for (e.g. differences in population characteristics)	Requires detailed information on the characteristics of policy site(s)
Meta-analytic value function transfer	Use a value function estimated from the results of multiple primary studies to estimate ES values at policy site(s)	Allows differences between study and policy sites to be controlled for (e.g. differences in population characteristics, area of ecosystem, abundance of substitutes etc.). Practical for consistently valuing large numbers of policy sites.	Requires detailed information on the characteristics of policy site(s). Analytically complex

[14] See Rosenberger and Stanley (2006) for a discussion of the sources of transfer errors.

6.2.4.4 Scaling up ecosystem service values for national reporting

The currently available information on the value of ecosystem services is mostly for relatively small spatial scales (e.g. individual ecosystems). Assessments of changes in ecosystem service provision at larger geographic scales, e.g. national level reporting of ecosystem services, require the “scaling-up” of value information. The term “scaling up” is used to describe the transfer and aggregation of values that have been estimated for localised changes in individual ecosystem sites to assess the value of simultaneous changes in multiple ecosystem sites within a large geographic area (e.g. country or region).

At the level of individual ecosystem sites, marginal unit values for ecosystem services are likely to vary with the characteristics of the ecosystem site (area, integrity, and type of ecosystem), beneficiaries (number, income, preferences), and context (availability of substitute and complementary sites and services). The transfer of values to an individual ecosystem site needs to account for variation in these characteristics between study sites and the policy site. Localised changes in the extent of an individual ecosystem may be adequately evaluated in isolation from the rest of the stock of the resource, which is effectively assumed to be constant.

When valuing simultaneous changes in multiple ecosystem sites within a region, however, it is not sufficient to estimate the value of individual ecosystem site values and aggregate without accounting for the changes that are occurring across the stock of the resource. As an environmental resource becomes scarcer, its marginal value will tend to increase. This means that multiplying a constant marginal value by the change in area of an ecosystem site, as is often done in scaling up exercises, is likely to underestimate the value of the change.

Scaling up ecosystem service values: strengths and weaknesses

	Strengths	**Weaknesses**
Scale-up values without accounting for changes in stock	Relatively simple	Likely to underestimate the value of ecosystem change at national scale
Scale-up values accounting for changes in stock	Provides a more accurate value of ecosystem change at national scale	Analytically complex. Requires information on how marginal values change with changes in stock of resource

6.2.4.5 Quantifying and reporting uncertainties

Finally, turning to consider the issue of uncertainty it is obvious that in almost all cases the value of non-market goods will not be estimated with complete certainty. The question therefore becomes, how much uncertainty is too much. Simplistic assessments of the ‘size’ of uncertainty can be misleading and are not comparable across contexts. However, arguably the simplest and most general answer to this question is that the degree of uncertainty becomes unacceptable when a valuation estimate no longer provides information that enables better decisions to be made. For example, if the level of uncertainty is such that the analyst can still tell whether, say, benefits (with uncertainty) are still clearly larger or smaller than costs, then that information helps the decision and the level of uncertainty is acceptable.

The magnitude of uncertainties needs to be quantified and communicated in order to provide an understanding of the robustness of ES national accounting. This recommendation extends to all steps in the assessment process and not just valuation.

Quantifying uncertainties: strengths and weaknesses

	Strengths	Weaknesses
Qualitative description of uncertainty	Simple and easy to communicate	Lacks measurement of the scale of uncertainties
Limited quantification of uncertainty	Simple and easy to communicate	Potentially misrepresents the strength of information
Extensive quantification of uncertainty	Provides a full picture of the uncertainties involved in valuation of ES	Data and analytically complex; Difficult to communicate

6.2.4. Consistency with the System of National Accounts

There are a number of on-going initiatives that aim to develop recommendations for integrated natural capital accounting and the incorporation of ecosystem service values in national accounts. These initiatives are at various stages of development and closely linked to already existing satellite accounting systems around the core SNA in several countries, focusing primarily on provisioning services such as timber and abiotic resources such as subsoil minerals. An important question is to what extent ES can be fully integrated into the core SNA or included as satellite accounts around the SNA, either in physical or monetary terms. The approach taken will (or should) ultimately depend on the question one would like to see answered.

Guidelines for environmental accounting that are consistent with the international standard System of National Accounts (SNA) are provided in in the 2012 System of Environmental-Economic Accounts (SEEA) central framework. The SEEA central framework is a system for organizing statistical data for the derivation of coherent indicators and descriptive statistics to monitor the interactions between the economy and the environment and the state of the environment to better inform decision-making. Subsystems of the SEEA central framework elaborate on specific resources or sectors, including Energy, Water, Fisheries, Land and Ecosystems, and Agriculture. These 'sub-systems' are fully consistent with the over-arching SEEA, but provide further details on specific sectors and try to build bridges between the accounting community and the community of experts in each specific subject area. The SEEA central framework represents, to a large extent, a fixed set of the options described in Choice Levels 2-4 (sections 6.2.1 – 6.2.4).

The SEEA guidance on experimental ecosystem accounting is likely to encompass a broad description of the conceptual framework, which will include discussion on the scope and purpose of the accounts along with the proposed accounts, the classification of ecosystem services, the definition and measurement for the ecosystem accounting units and the valuation and recording methods of physical and monetary flows and stocks (United Nations Statistical Division, 2011). A new version of SEEA volume 2 was agreed upon by the UN Statistical Committee in February 2013, aiming to provide guidelines on extending the SEEA volume 1 in an experimental way.

The strengths and weaknesses of ensuring consistency with the SEEA central framework are listed below. Strengths and weaknesses of satellite accounting versus full integration of natural capital accounting into the core SNA are given in the table below that. Box 1 provides an overview of the challenges and lessons learned in setting up the integrated hydro-economic accounting system for the Netherlands and illustrates the different indicators derived from a set of satellite accounts around the SNA.

Consistency with the System of National Accounts: strengths and weaknesses

Strengths	**Weaknesses**
Consistent and coherent international accounting framework, which allows for international comparison between EU Member States	Restrictive in terms of the ecosystem services that can be included in the system, i.e. only those for which market prices are available. This clearly omits many of the most economically important (in terms of contribution to human welfare) ecosystem services
Flexible framework in that it allows EU Member States to decide which type of natural resources and ecosystem services they want to include based on national data, information needs and data availability	Establishing an integrated environmental-economic account is time consuming and requires an institutional (statistical) infrastructure (Statistical Office) with a mandate to collect, compile and publish the accounts on an annual or bi-annual basis
	High recurring maintenance costs: initial investment costs may be substantial and afterwards the information system has to be regularly updated and maintained in order to remain relevant and useful for actual policy and decision-making, hence requiring a constant flow of funding

Strengths and weaknesses of satellite accounting versus full integration of ecosystem services in the SNA

	Strengths	Weaknesses
Satellite accounting around core SNA	Provides the necessary and essential biophysical underpinning of the economic values associated with ecosystem services and abiotic resources and allows for the creation of integrated/coupled biophysical and economic growth indicators, allowing policy makers to assess the cost-effectiveness of their policies and the eco-efficiency of economic production and consumption	Requires the biophysical indicators and accounting framework to fit the geographical and temporal scales applied in the SNA, which may be hard given the fact that many ecosystem boundaries do not correspond with the administrative boundaries applied in the SNA (national level, one year) (for instance fitting water in a river basin into the boundaries of a country)
Full integration of ecosystem services in capital accounts in core SNA	Fully integrated inclusion of the economic value of ecosystem services and abiotic resources such as minerals in the SNA, providing a single comprehensive welfare indicator	Difficult given the strict rules and regulations related to National Accounting. There exists a discrepancy between the theoretical economic framework/model used to derive all-inclusive welfare indicators, including sustainable national income, and the practical statistical calculation rules underlying GDP, impairing most probably also the interpretation of GDP as a more comprehensive welfare measure, also after inclusion of ecosystem services capital accounts

An important issue for accounting is the distinction between ecosystem services for which values are already implicitly accounted for in conventional SNA (e.g. pollinators to agricultural production) and those services whose values are not (e.g. open access recreation in nature areas). In the former case, the challenge is mainly attribution: what fraction of value added of a sector or the economy should be attributed to what ecosystem services? In the latter case, conventional GDP will be augmented by hitherto unpriced goods and services (e.g. carbon storage or flood protection by wetlands).

For the ecosystem services within the *production boundaries* of SNA (those that are implicitly accounted for), market prices can be used to derive their values. However, in theory one would need to rely upon empirically estimated production function approaches (e.g. bio-economic modelling) to assess the marginal value of the ecosystem service involved. For other ecosystem services, where such market prices do not exist, it is necessary to "conduct valuations at a scale which is feasible, credible and policy relevant. In order for these valuations to be consistent with the SNA, they will need to approximate prices, and not to attempt to represent a holistic or social identity of value" (United Nations Statistical Division, 2011, p.9).

There are different views on what valuation methods are "feasible, credible and policy relevant". Weber (2011) for example, asserts that "compatibility with SNA excludes some methods frequently used in cost-benefit analysis (typically contingent valuation)..," and proposes to use "remediation costs" to value the degradation of ecosystems. In contrast, UK NEA, has, for reasons of consistency with economic theory, "excluded the use of restoration or replacement costs as a proxy for the value of ecosystem services"(UKNEA, 2011, p. 1072). Glenn-Marie Lange of the WAVES project summarizes this issue as follows: valuation techniques must stay within the SNA concept of value, that is: market-based/marginal. Cost-based, remediation, approaches are "third-best" (Lange, 2011).

The choices EU Member States have here is whether they are interested in linking up with this existing framework of integrated environmental-economics accounts. If they do, they have a number of additional choices to make, amongst which:

- Which ecosystem services should be included in the environmental accounts (from the CICES set)?
- From which year onwards?
- On an annual, bi-annual or 5-yearly basis?
- At which geographical scale? National like the national accounts or at a lower disaggregated spatial scale accounting for the geographical provision level of ecosystem services provided for example by river basins? Available biophysical and monetary data and information at different spatial scales will have to be made compatible through consistent aggregation and disaggregation procedures.

Box 1: challenges and lessons learned in setting up an integrated hydro-economic accounting system

Based on the National Accounting Matrix including Environmental Accounts and linked to the implementation and reporting requirements of the EU Water Framework Directive, an integrated water accounting system was developed for the Netherlands in 2004, called National Accounting Matrix including Water Accounts for River Basins NAMWARiB. Physical water and pollution flows are linked in this system of integrated accounts to the core System of National Accounts, and disaggregated to the different river basins in the Netherlands using GIS. Time series linking financial transactions in economic sectors to water abstraction, wastewater discharge, corresponding pollution loads of close to 100 chemical substances (including nutrients, heavy metals and other chemical compounds which are systematically monitored in Dutch water bodies), and wastewater treatment are available since 1996. Annual financial flows related to the water services as defined in article 2 in the WFD (about which Member States have to report cost recovery rates to the European Commission) are distinguished explicitly in NAMWARiB. This integrated water accounting system was the basis for another macro-economic modelling exercise using an updated version of the existing applied general equilibrium model for the Dutch economy to estimate the macro-economic and sector impacts of different WFD implementation scenarios (Dellink et al., 2012).

Basically, the structure of NAMWARiB consists of three parts (see the Table below):

- An economic account (the first 10 accounts, all in millions of euros).
- A water extraction and discharge account (account numbers 11 and 13 in millions of cubic metres).
- An emission account (account numbers 12 and 14 in kilograms).

Account nr	1-10	11	12	13	14
1-10	NAM (economic); mln Euros				
11	Water balance; mln m^3				
12	Emission balance; kg				
13	Water balance; mln m^3				
14	Emission balance; kg				

The first accounts for the emission of substances and water extraction and discharge, account numbers 11 and 12, represent the flows. The second account (account number 13) for water extraction and discharge describes changes in stocks, while the second account (account number 14) for emissions describes the contribution of various substances to 'environmental themes' such as eutrophication or the dispersion of heavy metals in water. Also this is significantly different than the flow accounts. To stress these differences, the accounts are not presented consecutively, but alternating in NAMWARiB.

A number of challenges exist when trying to extend the existing core System of National Accounts with environmental accounts. These include:

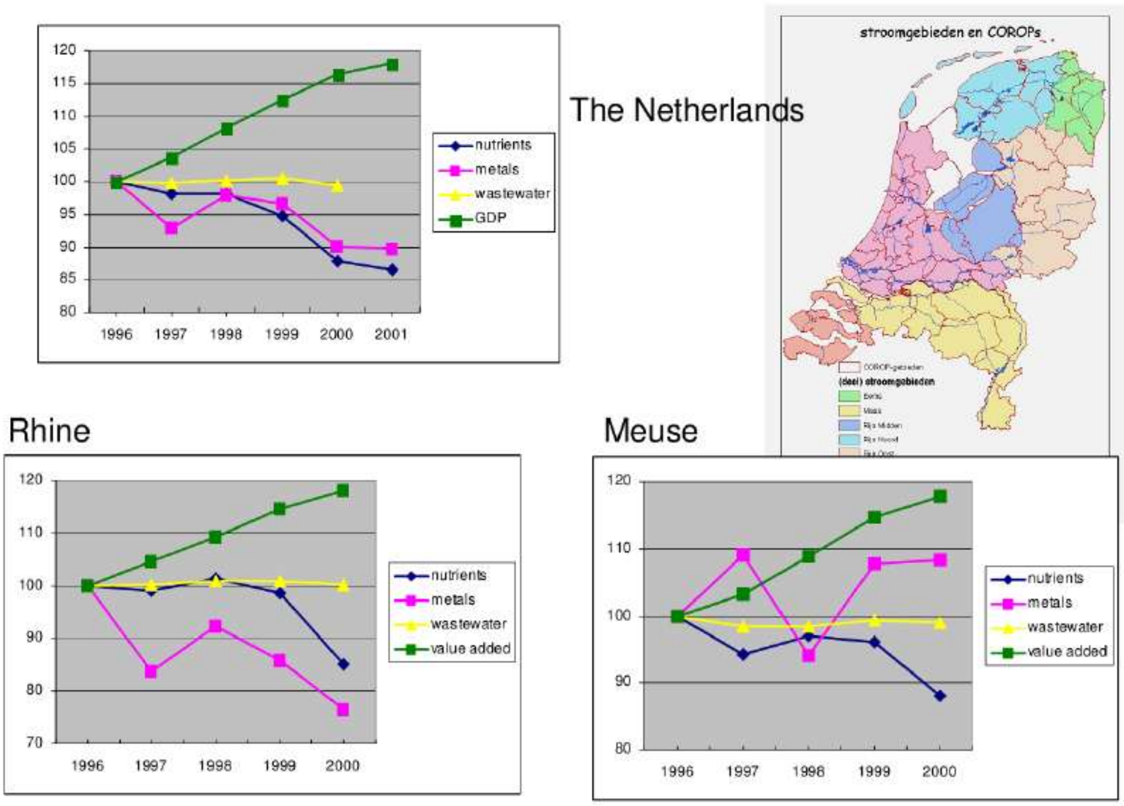
- Different statistics from different data sources
- Different classifications of sectors
- Different monitoring and management scales
- Different sampling and aggregation procedures
- Confidentiality issues
- Data from observations, calculations and model simulations

Box 1: continued

The overview below illustrates the different scales at which both economic and hydrological data are available for integrated river basin accounts in the Netherlands:

Economic data	Hydrological data
• National	• National
• Province (12)	• River basin (4)
• Corop (40)	• Regional government (8)
• EGS (129)	• Sub river basins (17)
• Municipalities (>500)	• Water boards (56)
• Postal codes (>5000)	• PAWN districts (80)
	• Water discharge units (>1000)

The development of the National Accounting Matrix including Water Accounts at River Basin level for the Netherlands took approximately 2 years and an initial investment sum of several hundreds of thousands of Euros. It required the signing of memoranda of understanding at the highest levels between the institutions that collect different types of data needed for putting such an integrated information system together. These water accounts are now a standard component of the Dutch Environmental Accounts (e.g. Statistics Netherlands, 2011). An example of the different indicators derived from the integrated information system based on satellite accounts is shown in the figure below.



Source: Brouwer, R., Schenau, S. en van der Veeren, R. (2005). Integrated river basin accounting and the European Water Framework Directive. Statistical Journal of the United Nations Economic Commission for Europe, 22(2), 111-131.

Finally, it may be useful to put these ongoing initiatives in a historical perspective. The discussion about greening the SNA is an old one, going back to the 1960s-1970s, where economic growth models provided the theoretical basis for measuring progress towards sustainable development and greening the National Accounts (e.g., Solow, 1974; Hartwick, 1977; Pearce and Atkinson, 1993; Asheim, 1994). Several initiatives were developed using ad hoc “correction mechanisms” (typically consisting of the subtraction of so-called environmentally defensive expenditures and depreciation of natural capital) to arrive at adjusted national income measures like the Index of Sustainable Economic Welfare (ISEW). In this rather old discussion, the imputation of monetary values to all market and nonmarket flows of benefits and damages from natural resources and ES during past, present and future periods of economic activity (that some of the ongoing initiatives reviewed here seem to head towards) is but one way to inform policy and decision-making about society’s progress towards wider macro-economic welfare and well-being. Alternative approaches were explored in a number of EU funded research projects, including the project GREENSTAMP (Brouwer et al., 1999).

In the latter project, full monetization of all flows of ES and natural capital degradation in the core SNA for the purpose of estimating a green or sustainable GDP was questioned due to (i) the contrasting hypothetical nature of such an exercise and resulting sustainability measure vis-à-vis the actual financial transactions currently monitored and reported in the SNA, and (ii) the assumptions needed to be made that everything else in the economy would remain the same if nonmarket ES and natural capital degradation would be monetized and exchanged in markets like the rest of the marketed produced goods and services currently monitored and reported in the SNA. Instead, a macro-economic modelling approach was proposed based on an integrated accounting system (linking the SNA to a set of physical satellite accounts) to assess the necessary macro-economic and sector adjustments needed to reach environmental standards associated with different levels of ES provision, distinguishing between ex post (how the economy would have looked like if ES would have actually been accounted for in existing market systems) and ex ante (how the economy can look like in the future if ES are accounted for in existing market systems) sustainable development paths.

6.3 Conclusions

Based on the above, the study's main conclusions are:

- Numerous initiatives are ongoing to classify, assess, value and report ecosystem services at national and regional level in different EU Member States. These initiatives are highly diverse and reflect the wide array of options available for assessing ecosystem services. In this report we have outlined these options and described the strengths and weaknesses of each alternative.
- In order to allow comparisons across EU Member States, there remains a strong need for further harmonization of the various approaches, or at least the recognition where main commonalities and especially differences exist in these approaches.
- None of the ongoing initiatives have yet reached a stage of full maturity in terms of finalized frameworks and application. Currently, there is a need for these initiatives to go through a period of testing to further develop and explore the possibilities and impossibilities based on available knowledge, data and information in individual Member States to integrate the value of ecosystem services in existing accounting and reporting frameworks.
- The CICES classification and the MAES guidance document will be instrumental in providing an appropriate and consistent framework for this at pan-European level, and allow for comparisons between Member States. The forthcoming TEEB Guidance Manual for country studies will provide guidance on scoping national ecosystem service assessments.
- Key to the successful integration of ecosystem services in existing, modified or new accounting or reporting formats is to (1) establish reliable, scientific links between the biophysical provision of ecosystem services and their economic use (and nonuse) values, and (2) take into consideration the existence of extensively tested guidelines for environmental accounting over the past decades by statistical offices in order to create and maintain a consistent and coherent System of National Accounts.
- As a result, when pursuing the full integration of ecosystem services in capital accounts in the core SNA, a careful stepwise integration via satellite accounts seems to be the most promising way forward, keeping the core SNA intact and making any modifications clearly and explicitly traceable throughout the accounting system. The development of both physical and monetary satellite accounts allows the advancement of frameworks and data collection for ecosystem services without interfering with the consistency and quality of information provided by the core system of national accounts.

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Annex 1. Summaries of MS national assessments

Czech Republic

Source: Presentation by Iva Honigova (Agency for Nature Conservation) to the workshop "Exchange on TEEB Processes in European Countries", 12 October 2011, Isle of Vilm.

A study has been completed on the value of grassland ecosystem services. The institutions involved were the Agency for Nature Conservation and Landscape Protection of the Czech Republic (ANCLP), the Charles University Environment Center, the Umweltbundesamt GmBH (UBA), with financial support from the European Topic Centre on Biological Diversity. The study was conducted during 2010-2011. The main objectives of the study were:

- To explore relationships among ecosystem services and biodiversity
- To assess of ecosystem services provided by grasslands
- To explore methods and options to assess trade-offs among ecosystem services provided by grasslands under various use

The study focused only on grassland ecosystems, including eight categories of semi-natural habitats, pastures and managed grasslands (dry grasslands, alluvial meadows, mesic grasslands, seasonally wet and wet grasslands, alpine and sub-alpine grasslands, forest fringe vegetation, salt marshes, heathlands).

The categorization of ecosystem services follows the TEEB typology. The ecosystem services that were assessed are food provision, climate regulation, regulation of invasive species, erosion control, water flow regulation, water filtration, and recreation and tourism.

The valuation methods applied were selected for their applicability to each ecosystem service and include market prices, marginal abatement cost, maintenance cost, damage cost avoided, replacement cost, and stated preference valuation.

Some of the identified weaknesses of the study in terms of achieving an influence on decision making are that the methods of ES quantification and valuation are not considered to be reliable and that there is a preference on the part of decision makers for straightforward information that is understandable to public.

Estonia

Correspondence with: Lilika Käis (Ministry of Environment)

There is currently no national TEEB study in Estonia or immediate plans to carry out one. Similarly, there is no national ecosystem service mapping exercise covering Estonia. Nevertheless, the Ministry of Environment is planning to organize a seminar in the Autumn with national experts in ecosystem services (which could help form a team entrusted with a national TEEB study at a later stage).

Estonia is in the final stages of preparation of its “National Conservation Development Plan until 2020” as part of its National Biodiversity Strategy and Action Plan. The plan is likely to be adopted later in the summer. The plan has integrated the strategic goals of the Global Strategic Plan for Biodiversity until 2020 adopted in Nagoya in 2010 and of the EU Biodiversity Strategy to 2020 and its main targets include: “a. halting deterioration, and achieving considerable improvement of the status of the species and habitats, b. granting functional connectivity between ecosystems (e.g through green infrastructure); c. combating invasive alien species; d. enhancing other sector's (e.g. agriculture, forestry etc) positive contribution to biodiversity conservation; e. ratifying Nagoya protocol”. Additionally, “valuation and restoration of ecosystem services” has been identified as main objective. Planned actions extend beyond the assessment of the status of ecosystems and related services and will also include measuring “their economic value, taking these values into consideration on different resource use levels, as well as raising the awareness of the general public about the values of nature”.

At a more disaggregated level, there has been a range of project activities on the valuation of ecosystem services, although often with a biased focus on agriculture. For example:

1. “The demand for protected forest by working age population of Estonia”, study commissioned by the Ministry of Environment (2011). The study made use of contingent valuation techniques to estimate values of ecosystem services.
2. “Public benefits from different agricultural production types”, study commissioned by the Ministry of Agriculture (2012)
3. “Overview of ecosystem services and their economical value” , literature review by the Stockholm Institute branch in Talinn (2012)
4. “Assessing the economical value of bogs, on the example of Kuresoo bog”, study commissioned by the Ministry of Environment (2012)

The Ministry of Environment also organized a seminar in April 2012 on the different ecosystem service value assessments in Estonia.

France

There is an ongoing national Millennium Ecosystem Assessment. This focuses on:

1. Terrestrial ecosystems: land cover data (CORINE Land Cover 2006): 18 categories of ecosystems in France mainland national mapping
2. Aquatic and marine ecosystems: mostly land cover data (CORINE Land Cover and Carthage): 4 categories of aquatic and 4 categories of marine ecosystems

Mapping of ecosystems at three levels: national, 6 main river basins, 34 hydro-eco regions

There are 43 ecosystem services analysed: Provisioning Services (e.g. food production, energy production, aquaculture, fishing, timber etc), Regulating Services (flood buffering, drought mitigation, water purification, erosion control, limitation of avalanches etc), Social Services (artistic inspiration, ecotourism, hydrotherapy, outdoor sport etc)

Difficulties: Distinguishing between serviced produced naturally by ecosystems and those by human activity, Scarcity in data for quantification, Weighing the share of each ecosystem for the production of each service, Scientific Validation of Results. More importantly thin on valuation.

Germany

Correspondence with Christoph Schröter-Schlaack (UFZ) and information provided during the presentation given by the TEEB Germany team at the TEEB conference at UFZ in Leipzig.

Hungary

Correspondence with: Eszter Kelemen (Institute of Environment and Landscape Management

There are plans for a TEEB national study but nothing very concrete at this moment. Limited financial resources at the moment as a result of the ongoing economic crisis also hinder such efforts. Since 2010, ministries have been re-organised and as a result, the Ministry of Environment and Water has become part of the Ministry of Agriculture and Rural Development.

There has been a study on “The valuation of agro-ecosystems with participatory methods”, financed by the Hungarian Scientific Research Fund (2009-2012). The study looks at different types of agro-ecosystems (forest, grasslands, orchards) at 4 different areas in Hungary and attempts to grasp appreciation of corresponding ecosystem services by local farmers with the use of group-based techniques. Unfortunately the study involves only social scientists without detailed input from natural sciences. It also does not involve any monetary valuation of agroecosystem natural services. Provisioning and regulating services are often more obvious to local farmers but extent of awareness varies according to geographical area and environmental issues at stake (e.g. in the Middle Great Plain, regulating services and water availability receive more attention as a result of the increased risk of desertification – similarly in hilly areas, soil erosion and forest-related ecosystem services are considered of more importance).

There are researchers specializing in monetary valuation of ecosystem services at the Corvinus University in Budapest. For example, Dr Zsuzsanna Marjajne Szerenyi has been involved in estimating monetary values of water systems in the Altal-Er catchment as part of the AQUAMONEY project. The study looks at several impacts on the local aquatic ecosystems (e.g. excessive nutrient loads (particularly nitrogen and phosphorous), overexploitation of surface water and groundwater resources, changes in river flow patterns, contamination with hazardous substances, degradation and loss of wetlands). The study makes use of contingent valuation and travel cost methods to derive values of ecosystem services, in combination with market values (e.g. water use cost by main economic stakeholders, loss of income due to bad water quality etc).

Ireland

Correspondence with: Craig Bullock (University College Dublin)

There is currently no national TEEB study in Ireland. There has been a comprehensive 2008 study, commissioned by the Biodiversity Unit of the Department of the Environment, Heritage and Local Government of Ireland on the “Economic and Social Aspects of Biodiversity: Benefits and Costs of Biodiversity in Ireland” The aim of the report is to identify the range of critical ecosystem services related to biodiversity in Ireland and provide approximate values of corresponding benefits. The study does not collect primary data on values but uses the benefit transfer method to generate values of services from other studies. The total value of ecosystem services (related to biodiversity) in Ireland (in terms of contribution to productive output and human utility) are estimated at €2.6 billion per year. The biodiversity benefits are categorised according to benefits accruing to agriculture (pollination, soil biota, pest control), forestry, marine environment (fish catch, aquaculture, swaweeds, waste assimilation), water (wetlands and flooding, fishing and recreation, waste assimilation, industrial abstraction). Provisioning, regulating and supporting services are considered with somewhat less attention given to cultural services (with the exception of recreation). Although the study does not pursue a cost-benefit comparison (policy costs vs. biodiversity benefits), it advocates generous spending on biodiversity protection based on a partial comparison of the marginal benefits of ecosystem services with current policy costs.

SYMBIOSIS is another project (involving the University College Cork, Trinity College Dublin (TCD) and University College Dublin) focuses on ecosystems services such as pollination, biocontrol by natural enemies, invasion resistance and the provision of habitat and corridor function. Study sites cover road schemes along an East to West transect of the Island of Ireland from Kerry to

Wexford, a long-term large scale experimental study on a 40km stretch of national road scheme and bioenergy crop field sites within the agricultural landscape of southeast Ireland. Project focused on mapping of ecosystem services rather than valuation.

ECORISK (Ecosystem services valuation for environmental risk and damage assessment) is a one-year project funded by the Environmental Protection Agency that aims to “examine the prospects for quantifying the economic value of ecosystem services for use within the Environmental Liability Directive, namely for compensatory remediation. Specifically, it will undertake a review of ecological research that has been conducted in Ireland where it has relevance to the assessment of ecosystem services and combine this with a national and international review of economic valuations of ecosystems or environmental goods. It will use this information to inform a database whereby policy makers and practioners would be able to search for data and advice on the methods needed to assess various levels of environmental risk or damage, indicating also the types and sources of data required. The research will propose, with examples, valuation methods that are appropriate for particular circumstances and make recommendations for the future application and refinement of methods within the context of the ELD and other policy needs”.

Professor Cathal O’Donoghue at Teagasc (the agriculture and food development authority in Ireland) has also carried our research in recent years with a specific focus on valuing water services in Ireland.

Italy

Correspondence with: Rocco Scolozzi (University of Trento)

Not aware of plans for a TEEB national study in Italy. Dr Scolozzi had an extensive consultation recently with 46 experts on ecosystem services (from different disciplines and 10 different academic institutions) – none worked on a nationwide project on valuation of ecosystem services. The recent study by Scolozzi et al in Ecological Indicators (Delphi-based change assessment in ecosystem service values to support strategic spatial planning in Italian landscapes) provides monetary valuation estimates at the province level for Italy using a modified version of the benefit transfer method (where “experts also provide shared and reliable inferences about the potential for ES provisioning by land covers”). The study looks at the following ecosystem services (climate and atmospheric gas regulation, disturbance prevention, freshwater regulation and supply, waste assimilation, habitat support, nutrient regulation, recreation, aesthetic and amenity, soil retention and formation, pollination). In terms of land cover classes, the focus lies on cropeland, pasture, forest, urban green areas, fresh water wetlands, salt water wetlands, fresh water).

There has been an inventory (INFOCARB) of organic carbon stored in different types of forest ecosystems in the Trento region. This is a collaborative project of the Fondazione Edmund Mach and the DG Joint Research Centre.

Professor Geremia Gios (University of Trento) makes use of contingent valuation to measure values of forest ecosystem services. In a recent co-authored study (The development of forest accounting in the province of Trento (Italy), *Forest Economics*), he measured the combined value of provisioning and recreational/aesthetic/ecological forest services.

Lithuania

Correspondence with: Vytautas Narusevicius (Environmental Protection Agency)

There is an ongoing initiative on "Lithuanian ecosystem services inventory and valuation". This project runs from 2010 to 2014 and has three stages comprising seven tasks:

Stage I (2010 – 2011.02):

> Task 1. To establish a primary set of ecosystem services and goods, relevant to Lithuania.
>
> Task 2. To elaborate and implement a small-scale national case study, demonstrating ecosystem services and their importance to public and policy makers as well as visualizing and proving procedures and methods for inventory and valuation.

Stage II (2011.03 – 2012):

> Task 3. Based on experience and available data, establish a sufficient network of model sites, that are representative of the regions of Lithuania in terms of demographic, social, natural conditions and ecosystem service characteristics;
>
> Task 4. To identify, map and evaluate ecosystem services in one of the selected model sites.

Stage III (2013 – 2014, depending on funding availability):

> Task 5. To identify, map and evaluate ecosystem services in the rest of the selected model sites.
>
> Task 6. To prepare main methodological recommendations, procedures and examples for the mapping of ecosystem services in the whole territory of Lithuania by merging data and information, received during 1-5 tasks implementation, and best available land cover/statistical/monitoring/inventory data;
>
> Task 7. To establish data and information background for ecosystem services mapping in the whole territory of Lithuania (the final result should include information, necessary for overall mapping and evaluation of the main ecosystem services in Lithuania, excluding marine ecosystems).

The current stage of the project in July 2012 is that a comprehensive network of 8 model areas, representing share of ecosystem services in Lithuania territory, has been established as a primary data source and background for further evaluation on the national scale. Field work and surveys are ongoing at one of the selected model sites, namely Tytuvenai Regional Park.

The institution(s) involved in this assessment are:

- Implementation by the Center for Environmental Solutions,
- Experts from NGOs: Lithuanian Theriological Society, *Lithuanian* Society for Bat Conservation, Lithuanian Botanical Society,
- Other institutions: Tytuvenai Regional Park Direction, forest enterprises, local joint stock companies, Mykolas Romeris University (publishing first results).

The project plans to conduct a total of nine case studies. Currently one small scale case study is complete with a pilot study in the selected model site currently underway. A further seven studies in the remaining identified study areas is planned. It is worth noting that all these case studies (with the exception of the small-scale "show case" study) are not developed for some specific policy evaluation (specific place, ecosystem or service evaluation) – but that they are designed to establish a data and valuation pool for the further extrapolation, combined with other available data (e.g. statistical and spatial), into national ecosystem services mapping/evaluation.

The main ecosystems addressed in the study are inland water, forests, wetlands, grassland, cultivated/agriculture land, peri-urban. Marine and coastal ecosystems are not covered by the assessment.

The main ecosystem services addressed are provisioning (food, raw materials, water), regulating (erosion prevention, air quality, carbon sequestration, hydrological regime stability, habitat provision, pollination), cultural (recreation and tourism, cognitive development, aesthetical enjoyment), supporting (maintenance of genetic diversity).

The categorization of ecosystem service categorization used is principally the TEEB classification with some elements from the MA (such as supporting services instead of habitat services, and pollination as supporting, not regulating service, etc.).

The scale of analysis ranges from local to regional. Selected regional case studies will serve to have a representative coverage for the national evaluation. Analysis will make use of high resolution aerial pictures for some services; whereas for the extrapolation of results to the national level will use low resolution land cover and national inventories maps.

The scale of aggregation at which results are reported will be at the regional and national scales. Extrapolation of data from the seven pilot sites will be made to the regional and national scale using statistical data of ecosystems coverage and mapping information.

The valuation methods to be used include market prices, cost-based (substitution) pricing, contingent valuation, value (benefit) transfer, travel costs, hedonic pricing methods. The primary research elements of the projects also include in-situ observations, territory mapping, interviews, questionnaires, and spatial data analysis for ecosystems services stock/availability and use intensity evaluation.

The key strengths of the project are considered to be:

- Awareness raising for politicians, local society, protected areas managers, environmental science institutions and NGOs. This is done by introducing easily understandable local examples of the idea and importance of ecosystem services;
- Specialized NGOs network – establishing support group for national assessment purposes. Experts network for future training and data collection and analysis teams;
- Testing of extrapolation-based ecosystem services mapping and valuation methods, development of selected value transfer method;
- Establishing a strong data/information background for the full-scale national mapping and evaluation of ecosystem services.

The key limitations of the project are identified as:

- Mainly direct and final services will be evaluated;
- Cultural and supporting services mapping and valuation will be limited;
- Trans-boundary issues with the neighboring countries will not be involved;
- Marine and sea-shore ecosystem services are excluded

Norway

Correspondence with David Barton and Henrik Lindhjem (Norwegian Nature Institute NINA)

There is not much work yet done yet on the “Norwegian TEEB”. A public committee has been established to write a white paper/report on the value of ecosystem services in Norway. This report will be finished around August 2013. During the process there are some small projects summarizing literature and providing text for the report (but no money for new valuation work). The literature on the value of ecosystem services from forests is currently being summarized, although in principle all ecosystems will be covered. Part of the work will be pointing out gaps in current knowledge/research (which are large in Norway). Also, the committee is quite sceptical of valuation, so part of the job is to demonstrate value/benefits in other ways than pure economics. TEEB Norway has not progressed very far yet. Currently the team is working on clarifying ecosystem service frameworks (MEA, TEEB etc) and defining terms that will be used in Norwegian and a rough outline of the study.

Poland

Correspondence with Małgorzata Stępniewska and Andrzej Mizgajski (Adam Mickiewicz University, Poznań) and Anna Bartczak (Warsaw Ecological Economics Center - WEEC)

The Adam Mickiewicz University are involved in a number of project related to ecosystem services assessment in Poland. These include:

- Economic valuation of ES resulting from waste water management improvement in the country side – local/regional level approach (Wielkopolska region);
- Economic valuation of ecosystem cultural services – aesthetic value of landscape elements reflected in property prices (case study of Poznan urban area). This research is ongoing;
- ES as an economic and social factor for decision makers on local municipal level – ongoing doctoral thesis;
- Preparation and organization of the first Polish scientific symposium titled 'Ecosystem services as a transdisciplinary area of research and application' (ECOSERV 2010, Poznan 16.06.2010) with 19 presentations and over 80 participants.
- Preparing the second edition of symposium ECOSERV. ECOSERV 2012 will be held in Poznan, on September 24.

Most research is based on the Millennium Ecosystem Assessment but there is also development of new approaches concerning ecosystem assessment on the local level. There are applications of modelling as well as statistical and economic methods for ecosystem assessment.

The Warsaw Ecological Economics Center (WEEC) is involved in a number of European projects that address ecosystem service assessment including NEWFOREX, POLFOREX, and RECOCA.

Slovakia

Correspondence with Jana Spulerova (Institute of Landscape Ecology)

The Slovak Ministry of Environment has started an initiative on the assessment of ecosystem services at the national level. The main project partners are the Slovak Environmental Agency and the State Nature Conservancy. The assessment is currently at the beginning of the discussion process. The intention is to evaluate ecosystem services based on land use changes.

The Slovak Institute of Landscape Ecology in currently involved in two projects that assess the value of ecosystem services. The first is a socio-ecological study of landscape and biodiversity change in the mountain area of the Poloniny National Park in the context of global changes. The timeframe for the project is 2010-2012. The main policy issue to be addressed is the impact of global environmental changes on ecosystem services and the development of a proposal for suitable management for maintenance of ecosystem services. The ecosystems considered in the study are semi-natural grasslands (meadows, pastures, non-forest vegetation, abandoned grasslands, wetlands). The study uses the TEEB categorization of ecosystem services. The research methods employed include a synthesis of biological research in the target region; detailed study of socio-ecological interactions in the area, including ecosystem services provision; and proposal of causal chains of human-nature processes in the landscape.

A second ongoing project of the Slovak Institute of Landscape Ecology is an assessment of the significance and ecosystem services of historical structures of agricultural landscapes. The project involves three case studies and runs from 2010-2012. The main policy objective is to draw attention to ecosystem services of traditional agricultural landscapes and support sustainable management of this landscape. The ecosystems included in the assessment are semi-natural ecosystems of traditional agricultural landscape. The ecosystem services addressed are regulating services (assessment of water and soil regulation, visualization of landscape view, etc.); habitat services (maintenance of genetic diversity, maintenance of life cycles of migratory species); cultural ecosystem services (recreation and ecotourism, aesthetic, inspirational, educational, sense of place, cultural heritage); and provisioning services. This project uses the CICES ecosystem service categorization. The scales of analysis and aggregation are local case studies. The research methods used include GIS tools, visualization of landscape views, assessment of indicators, and sociological survey. The key strength of the project is that it provides new knowledge on goods and ecosystems services provided by ecosystem of traditional agricultural landscape for representative case study sites. The key limitation is that not all ecosystem services are studied for each case study site.

Spain

There is a completed national Millennium Ecosystem Assessment. The complete synthesis report can be found at www.ecomilenio.es but report available only in Spanish.

“The aim of the Spanish Millennium Ecosystem Assessment (EME) is to generate interdisciplinary scientific knowledge relevant to public and private sectors on the impact of changes in aquatic and terrestrial ecosystems on human well-being, as well as possible response options. Furthermore, the project contributes to the accomplishment and development of the Spanish Natural Heritage and Biodiversity Act (Law 42/2007).”

“The assessment has been developed at different scales, i.e. national, sub-national (i.e., Andalusian and Biscay), fourteen ecosystems, and four case studies at local level. EME is organized around a “core group” of people composed by scientists from universities promoting the project, the staff from the Biodiversity Foundation and various governmental agencies. This group coordinates a large team of researchers from different areas of biophysical and social sciences.”

Focus on Provisioning, Regulating and Cultural Services. Limited focus on valuation. VANE Project (Valuation of Natural Capital) – Report in Spanish

Sweden

Correspondence with: Louise Hård (Swedish Society for Nature Conservation)

There is currently no national TEEB study in Sweden or immediate plans to carry out one. There has been a Nordic project ("Applying the TEEB-approach to 3 Nordic municipalities") piloting the TEEB for local and regional decision-makers in 3 municipalities in 3 Scandinavian countries (Sweden, Denmark and Finland; see also teeblocal.wordpress.com). This mainly consisted of workshop discussions where local land-owners and NGOs where also involved. Often participants have been more interested in the less obvious ecosystem services (e.g. cultural, regulating). Dr Hård has also held three interactive meetings at the Swedish Ministry for Environment with representatives from municipalities, regions, government bodies, and other organisations to discuss and gather knowledge and experience on how to operationalize ecosystem services in management and make their values more seen.

There has also been, an international research network (BalticSTERN, see http://www.stockholmresilience.org/balticstern) doing cost-benefit analysis regarding the environmental problems of the Baltic Sea and give guidance toward cost-effective measures and policy instruments. This is a collaborative project with partners from Sweden, Poland, Finland and Denmark. Main focus is on the marine environment and there is use of ecological and economic models values attached to ecosystem services and costs of interventions. Multiple ecosystem services are considered (food, recreation, inspiration and sources of science and education, biodiversity and resilience, habitat for flora and fauna, biogeochemical cycling. regulation of climate, atmosphere and hazardous substances, mitigation of eutrophication etc). Final report is expected to come out later this year.

United Kingdom

Correspondence with Ian Bateman (Centre for Social and Economic Research on the Environment – CSERGE)

The UK National Ecosystem Assessment (UK NEA), conducted in the period 2007-2011, was the first analysis of the UK's natural environment in terms of the benefits it provides to society and continuing economic prosperity. A follow on phase for the UK NEA is now underway. The following summary focuses, however, on the initial phase of work.

Institutions involved

The funding institutions for the UK NEA are the Department for Environment, Farming and Rural Affairs (DEFRA), National Environmental Research Council (NERC), Northern Ireland Environment Agency (NIEA), Scottish Government, Countryside Council for Wales, Economic and Social Research Council (ESRC), and the United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC).

The economic valuation analysis for the UK NEA was coordinated by the Centre for Social and Economic Research on the Global Environment (CSERGE) at the University of East Anglia. The team working on the valuation analysis of the UK NEA included 47 researchers from 17 different institutions:

- Centre for Social and Economic Research on the Global Environment (CSERGE), School of Environmental Sciences, University of East Anglia (UEA)
- School of Earth and Environment, University of Leeds.
- Plymouth Marine Laboratory, Plymouth.
- Department of Economics, University of Stirling.
- Department of Land Economy, University of Cambridge.
- Department of Economics, University of Birmingham.
- Royal Society for the Protection of Birds (RSPB), Sandy, Bedfordshire.
- School of Applied Sciences, Cranfield University, Bedfordshire.
- Department of Geography and Environment, LSE, London.
- School of Economics, University of East Anglia, Norwich.
- Forestry Research, Edinburgh.
- British Trust for Ornithology, Thetford.
- Land Economy & Environment, Scottish Agricultural College, Edinburgh.
- UK Energy Research Centre, London
- CentER, Tilburg University
- Faculty of Economics and Business Administration, Vrije Universiteit (VU) Amsterdam
- School of Earth and Environment, University of Leeds
- Department of Policy Analysis, Aarhus University, Denmark

Steps in the assessment process

The steps in the assessment process that are addressed by the UK NEA are the trends in environmental pressures, biophysical modeling of ES (land use change and habitat quality), valuation of change in subset of ecosystem services, and policy and scenario appraisal. The NEA provides an in-depth biophysical assessment of the current status and past and future trends in ecosystem service provision, and the economic valuation of past, current and future flows for a subset of ecosystem services. The first phase of the UK NEA does not address ecosystem service accounting in detail. One of the objectives of the follow on phase is to develop the framework and address evidence issues for a Natural Capital Asset Check. This will provide input to the newly established Natural Capital Committee, which reports to the UK Treasury on natural capital accounting. The summary and review presented here focuses on the economic valuation component of the UK NEA work.

Ecosystems addressed

The economic valuation component of the UK NEA covers all UK terrestrial and marine habitats but with varying degrees of completeness in terms of the ES provided by each ecosystem. The variation in coverage is largely driven by the availability of data on the provision and value of ES for specific ecosystems. The specific ecosystems that are addressed include: marine habitats, coastal margins, woodlands, plantation forests, moorland, peatlands, agricultural land, crop land, inland wetlands, coastal wetlands, rivers, freshwater, National Parks, National Trust sites, nature recreation sites, local green spaces, urban green space. Table X provides an overview of which ecosystems are valued for specific ecosystems services. It is evident that, due to data availability, some ecosystems are more readily valued than others. For example, agricultural land and inland and coastal wetlands are valued for five separate ecosystem services.

Ecosystem service classification used

The UK uses the MA classification as a starting point but with adapts this to the concept of "final ES", and treats biodiversity differently from the MA.

The NEA work on valuation uses a broader definition of ES than that used by other chapters in the NEA report. It includes not only biotic ecosystem services but also a brief overview of specific abiotic natural resources such as renewable energy and climate. It also briefly considers wider issues such as raw materials, energy and ecosystem related employment. This is to illustrate the flexibility of the approach adopted and through this argue for a wider application of the approach than purely biotic ecosystem services. It is recognised that these additional discussions go beyond the remit of other analyses in the NEA but it is argued that they constitute a useful case for the extension of the principles underpinning the ecosystem service approach contributing to a possible harmonising of methods across all related fields of decision making.

Ecosystem services addressed

The valuation work of the UK NEA addresses only a subset of all ecosystem services due to data limitations for many ES and ecosystems. These gaps are explicitly identified and discussed. In particular groups of social values including non-use values for biodiversity are identified as being of potential high importance and requiring further research. The specific ecosystem services that are valued at a national scale in the UK NEA include: marine fisheries, other marine based biotic resources, pollination services, climate inputs to agriculture, timber, renewable energy, water supply, water quality, flood protection, carbon sequestration, climate as a source of amenity value, amenity value of green spaces, recreational use of natural areas, and non-use values for biodiversity (existence and bequest). Due to data limitations, these ES are not valued for all ecosystems that provide them, see Table X for the correspondence between ecosystems and ES addressed.

Scale(s) of analysis and aggregation of results

The scale of analysis for the valuations of ES varies across from highly local (e.g., 1 km grid cells for the amenity value of green spaces; 2 km grid cells for climate as an input to agricultural production; 5 km grid cells for recreational use of nature areas; individual wetland sites) to national (e.g., timber production, non-use biodiversity values). See Table X for details on the spatial scale of analysis for each ES valuation.

The scale of reported aggregation of values also varies across ES from regional (e.g., climate as an input to agricultural production), country (e.g., outdoor recreational use of nature areas), to national (UK) aggregation (e.g., water supply provided by wetlands).

Valuation methods

The valuation of ES presented in the NEA makes use of a combination of valuation results that are already published in the literature combined with new analyses which have been prepared partly or wholly for the NEA initiative. The selection of valuation methods is diverse and dependent on the ES in question and the availability of data and existing applications. The values presented are, wherever possible, an estimation of economic value but financial values have also been included for some ES in order to give an indication of the financial impacts when full economic estimation is not possible. The valuation method(s) used for each ES is presented in Table X.

Table X Summary of UK NEA ecosystem service valuations

Ecosystem Service	**Ecosystem(s)**	**Valuation method**	**Scale of analysis**
Marine food production	Marine	Market prices; Net factor income	UK
Woodland related food production (venison)	Woodland	Market prices	UK
Pollination services	Crop land	Production function method	UK
Maintaining genetic diversity:		No valuation	
Bioprospecting		No valuation	
Biodiversity: Non-use values	Agricultural land; inland wetlands; coastal wetlands; marine	Stated preference; Meta-analytic value transfer	UK agricultural land; wetland sites; UK wide marine conservation zone
Biodiversity: Non-use values		Revealed preferences (legacy values)	UK

Timber production	Plantation forests	Market prices	UK
Carbon sequestration	Coastal margins	Damage costs avoided (DECC, 2009)	UK
Carbon storage	Marine habitats	No valuation	
Water quality	Agricultural land; Inland wetlands; Coastal wetlands; Rivers	Market prices, replacement cost; stated preferences; meta-analytic value transfer	2 km grid; UK rivers; wetland sites
Water quantity	Inland wetlands; Coastal wetlands;	Replacement cost; Meta-analytic value transfer	Wetland sites
Flood protection: Inland	Rivers; Inland wetlands	Damage costs; Meta-analytic value transfer	UK; wetland sites
Flood protection: Coastal	Coastal wetlands	Stated preference; Meta-analytic value transfer	Wetland sites
Pollution remediation		No valuation	
Energy (renewable and non-renewable) and Raw Materials (fish meal, seaweed, aggregates)	Terrestrial and marine environments	Market prices	UK
Employment		No valuation	
Game hunting	Moorland, woodlands	Market prices	UK
Amenity value of warmer climate		Hedonic pricing	UK
The amenity value of nature	Local green space; rivers and freshwater; woodland; farmland; National Parks; National Trust sites; inland wetlands; coastal wetlands	Hedonic pricing; Stated preference; Meta-analytic value transfer	1 km grid; wetland sites
Education and environmental knowledge		No valuation	

Health		No valuation	
Agricultural food production	Climate as an input to agricultural production	Production function method.	2km grid
Carbon emissions and sequestration	Agricultural land (emissions); peatlands (emissions); woodlands (sequestration)	Damage costs avoided (DECC and Stern values)	2km grid
Carbon storage	Terrestrial habitats	No valuation	
Biodiversity: Non-use values		No valuation	
Recreation and tourism	Nature recreation sites	Gross expenditure; Meta analytic value transfer.	England only; 5 km grid
Urban Greenspace Amenity	Urban greenspace	Meta analytic value transfer	Census tracts

Adapted from Table 22.27 UK NEA (2011)

Annex 2. Summaries of reviewed initiatives (alphabetical order)

	ALTER-NET
Name of Initiative	ALTER-NET
Number of Partners/ Name of Key Institution(s)	26 institutes from 18 European countries (IVM, ALTERRA, ECNC, INBO, IRSTEA etc)
Countries Involved	UK, Norway, Sweden, Finland, Denmark, the Netherlands, Germany, Belgium, France, Spain, Italy, Estonia, Poland, Czech Republic, Slovakia, Austria, Hungary, Romania
Contact Person	Eeva Furman
Email	eeva.furman@ymparisto.fi
Website	http://www.alter-net.info/
Timeframe of Initiative	2004-
Steps in Assessment Process	Identification of common research priorities and development of a common research programme related to biodiversity issues. Further development of the LTER-Europe network of Long-Term Ecosystem Research sites (LTER) and Long-Term Socio-Ecological Research platforms (LTSER). Communication and knowledge transfer at interfaces such as scientist-to-scientist, scientist-to-policymaker and with the general public.
Approaches Used	Focus groups discussions with stakeholders, use of fuzzy cognitive mapping, computer simulated socio-ecological model based on DPSIR framework, experiments
Data sources	LTER InfoBase
Main Ecosystems Addressed	marine and terrestrial
Categorisation of ES	
Main Ecosystem Services Addressed	habitat/supporting, regulating
Scale of Analysis	
Scale of Aggregation	EU
Number of Case Studies	multiple (e.g. 6 case studies in Spain, Romania, Austria, Poland, Denmark and Finland on knowledge needs of conservation management in Natura2000 areas - see ALTER-net I)
Objectives	ALTER-Net's main objective is to develop lasting integration amongst its partner institutes, and others, all of whom are involved in biodiversity research, monitoring and/or communication. ALTER-Net is building upon a number of activities: •Identification of common research priorities •Further development of the LTER-Europe network of Long-Term Ecosystem Research sites (LTER) and Long-Term Socio-Ecological Research platforms (LTSER) •The ALTER-Net Summer School, which has been providing training for young researchers in inter-disciplinary approaches to biodiversity and ecosystems

	research since 2006 •Communication and knowledge transfer at interfaces such as scientist-to-scientist, scientist-to-policymaker and with the general public •Supporting the EU LifeWatch project
Results	Several contributions from support to the EU LifeWatch project to several project outputs.
Key strengths	originally started as an EU FP6 project, now is operating independently, much emphasis on communication and outreach, direct collaboration with TEEB
Key limitations	thin on valuation, main focus on biodiversity

	ATEAM - Advanced Terrestrial Ecosystem Analysis and Modelling
Name of Initiative	ATEAM - Advanced Terrestrial Ecosystem Analysis and Modelling
Number of Partners/ Name of Key Institution(s)	Wageningen University, University of East Anglia, PIK, Lund University etc
Countries Involved	Germany, France, Switzerland, the Netherlands, Sweden, Belgium, Spain, UK, Finland
Contact Person	Wolfgang Cramer
Email	Wolfgang.Cramer@univ-cezanne.fr
Website	http://www.pik-potsdam.de/ateam/ateam.html
Timeframe of Initiative	2001-2004
Steps in Assessment Process	A comprehensive modelling framework for predicting the dynamics of services provided by major European terrestrial ecosystems at a regional scale. Developing macro-scale indicators of society's adaptive capacity to changes in ecosystem service provision. Developing a range of scenarios for socio-economic development, land-use change, pollution levels, atmospheric composition and climate change up to the year 2100. Maintaining a dialogue with stakeholders to ensure the applicability of results for the management of natural resources. Developing a series of maps depicting regions and sectors that are especially vulnerable to global change.
Approaches Used	scenario analysis, forest modelling framework, development of several ecological models (e.g. RHESSys, FORCLIM)
Data sources	IPCC, Global Soil Data Task, CORINE, IMAGE2.2. SRES etc
Main Ecosystems Addressed	terrestrial
Categorisation of ES	
Main Ecosystem Services Addressed	habitat/supporting, regulating, provisioning
Scale of Analysis	varies but often 10'x10'
Scale of Aggregation	EU
Number of Case Studies	Multiple
Objectives	ATEAM's main objective is to assess the vulnerability of human sectors relying

	on ecosystem services with respect to global change.
Results	The study provides a wide range of environmental impact scenarios with spatially explicit projections of ecosystem services over time, including for the first time the variation over multiple plausible scenarios. This variation may be high, however, a considerable amount of it is due to the socio-economic pathway we choose to take. The set of multiple plausible global change scenarios showed severe changes in European climate and land use in the next century.
Key strengths	emphasis on collaborating with stakeholders
Key limitations	thin on valuation

	BEES - Belgium Ecosystem Services
Name of Initiative	BEES - Belgium Ecosystem Services
Number of Partners/ Name of Key Institution(s)	University of Antwerp, Flemish Institute for Technological Development, INBO, Catholic University of Leuven etc
Countries Involved	Belgium
Contact Person	Sander Jacobs
Email	sander.jacobs@ua.ac.be
Website	http://www.biodiversity.be/bees/static/show/1
Timeframe of Initiative	2010-
Steps in Assessment Process	1. Bring together key scientists, policy makers and organisations that are either already involved with ES-research or who might catalyse the ES-research. 2. Make an inventory on the ES expertise (a who's doing what). 3. To get a state of the art of ecosystem service related research in Belgium and to bring forward a methodology that could be used as a basis for an ecosystem assessment of Belgium. 4. Evaluate the opportunity to establish a "virtual" research institute on ES research in Belgium, covering the necessary expertise to contribute to large international research initiatives. 5. Formulate recommendations for scientific programmes and policy objectives.
Approaches Used	Inventory of ecosystem services, workshops for exchange of information amongst experts
Data sources	secondary
Main Ecosystems Addressed	
Categorisation of ES	
Main Ecosystem Services Addressed	habitat/provisioning/regulating/cultural
Scale of Analysis	several
Scale of Aggregation	Belgium
Number of Case Studies	
Objectives	It aims at identifying and stimulating research on ecosystem services in Belgium. It will do so mainly by organizing a series of workshops covering different aspects of Ecosystem Services (ES) Research.
Results	6 workshops on different aspects of ecosystem services research in Belgium: http://www.biodiversity.be/bees/static/show/10
Key strengths	There is a workshop dedicated to valuation techniques
Key limitations	Reliance on secondary information, mainly a network

	Biodiversity Information System for Europe - BISE
Name of Initiative	Biodiversity Information System for Europe - BISE
Number of Partners/ Name of Key Institution(s)	European Commission (DG Environment, Joint Research Centre and Eurostat) and the European Environment Agency
Countries Involved	EU
Contact Person	R. Spyropoulou (EEA)
Email	
Website	http://biodiversity.europa.eu/
Timeframe of Initiative	2005-
Steps in Assessment Process	BISE is a collaborative IT tool that organises information on biodiversity at the European level under five entry points: **Policy** (e.g. legislation and supporting activities related to EU directives, the EU Biodiversity Action Plan (BAP), pan-European and global policies); **Topics** (e.g. state of species, habitats, ecosystems, genetic diversity, threats to biodiversity, impacts of biodiversity loss, evaluation of policy responses); **Data** (data sources, statistics and maps related to land, water, soil, air, marine, agriculture, forestry, fisheries, tourism, energy, land use, transport, **Research** (important EU-wide research projects related to biodiversity and ecosystem services, improving the science-policy interface) and **Countries and networks** (national biodiversity reporting activities and information sharing by networks across national borders)
Approaches Used	data depository
Data sources	several sources: GEO BON, IUCN, CLC
Main Ecosystems Addressed	Agroecosystems, coastal, forests, wetlands etc
Categorisation of ES	
Main Ecosystem Services Addressed	mainly habitat/supporting
Scale of Analysis	different scales depending indicators/dataset
Scale of Aggregation	EU
Number of Case Studies	NA
Objectives	Main aim is to "strengthen the knowledge base and support decision-making on biodiversity" by providing a single entry point for data and information on biodiversity in the EU.
Results	Access to several databases: Biodiversity Data Centre, EMODNET, EuMon etc
Key strengths	showcases best available information at the EU level
Key limitations	it is only an information tool

	Common International Classification for Ecosystem Services
Name of Initiative	
Number of Partners/ Name of Key Institution(s)	University of Nottingham
Countries Involved	
Contact Person	Roy Haines-Young
Email	Roy.Haines-Young@Nottingham.ac.uk
Website	http://www.nottingham.ac.uk/cem/pdf/UNCEEA-5-7-Bk1.pdf; http://cices.eu/
Timeframe of Initiative	2010-
Steps in Assessment Process	
Approaches Used	
Data sources	uses existing data from other studies
Main Ecosystems Addressed	all
Categorisation of ES	proposal for new categorisation
Main Ecosystem Services Addressed	provisioning/regulating and maintenance/cultural
Scale of Analysis	global/local
Scale of Aggregation	
Number of Case Studies	NA
Objectives	
Results	
Key strengths	it does not replace other classifications but aims to provide a framework that enables the 'translation' between different classifications
Key limitations	steps need to be taken for implementation

	COMPREHENSIVE WEALTH ACCOUNTING
Name of Initiative	COMPREHENSIVE WEALTH ACCOUNTING
Number of Partners/ Name of Key Institution(s)	World Bank
Countries Involved	
Contact Person	Kirk Hamilton
Email	
Website	http://data.worldbank.org/data-catalog/wealth-of-nations
Timeframe of Initiative	1995-
Steps in Assessment Process	Assesses changes in different capital accounts (produced, natural, intangible)

Approaches Used	Market valuation (land rents)
Data sources	
Main Ecosystems Addressed	Agricultural land, forests, protected areas
Categorisation of ES	
Main Ecosystem Services Addressed	Provisioning
Scale of Analysis	National
Scale of Aggregation	
Number of Case Studies	
Objectives	The objective is to show that sustainable growth, is a process of building wealth and managing a diverse portfolio of assets: produced capital, natural capital, and human and social capital
Results	Comprehensive wealth accounts have been created for the years 1995, 2000 and 2005 for 150 developing and high-income economies
Key strengths	Simple; Signals unsustainable development
Key limitations	Limited coverage of ES (only market services)

	Eco-Delivery
Name of Initiative	Eco-Delivery
Number of Partners/ Name of Key Institution(s)	Stirling University, EIB
Countries Involved	UK
Contact Person	Frans de Vries
Email	f.p.devries@stir.ac.uk
Website	http://www.eco-delivery.stir.ac.uk/
Timeframe of Initiative	2010-2013
Steps in Assessment Process	This initiative is intended to examine issues related to the marketing of ES and not necessarily the assessment, valuation and accounting of ES. Spatial assessment of provision of and trade offs between ES; Valuation of ES for PES
Approaches Used	Lab and choice experiments
Data sources	Lab and choice experiments
Main Ecosystems Addressed	Wetlands and forests
Categorisation of ES	?
Main Ecosystem Services Addressed	Carbon sequestration, biodiversity, water quality
Scale of Analysis	Landscape
Scale of Aggregation	NA
Number of Case	2 - wetlands and forests

Studies	
Objectives	To evaluation how to both effectively and efficiently increase the supply of eco-system services from private land using market-based instruments
Results	
Key strengths	In depth analysis of specific issues such as joint production of ES and spatial configuration of habitats
Key limitations	No overall framework for assessing ES

	EEA ECOSYSTEM ACCOUNTING
Name of Initiative	EEA ECOSYSTEM ACCOUNTING
Number of Partners/ Name of Key Institution(s)	EEA
Countries Involved	
Contact Person	Jan-Erik Peterson
Email	Jan-Erik.Petersen@eea.europa.eu
Website	http://www.eea.europa.eu/publications/an-experimental-framework-for-ecosystem
Timeframe of Initiative	2009-
Steps in Assessment Process	Physical accounts (stocks & flows); partial valuation
Approaches Used	
Data sources	Based on existing Europe-wide datasets
Main Ecosystems Addressed	Socio-Ecological Landscape Units
Categorisation of ES	CICES (Common International Classification of Ecosystem Services)
Main Ecosystem Services Addressed	Provisioning/Regulation & Maintenance/Cultural
Scale of Analysis	1 km2 grid
Scale of Aggregation	National, Europe
Number of Case Studies	n.a.
Objectives	The objective is to implement simplified ecosystem capital accounts for Europe as a 'fast-track' initiative, based on the use of existing data and statistics. In addition to feasiblity assessment, the project aims at framing ecosystem accounts and identifying which indicators and aggregates could be delivered and integrated into enlarged national accounts
Results	Methodology described in EEA report http://www.eea.europa.eu/publications/an-experimental-framework-for-ecosystem
Key strengths	Consistent accounting framework, based on existing data and statistics
Key limitations	Valuation base don remediation cost; not linked to demand for ecosystem

	services

	EEA SCALING-UP
Name of Initiative	EEA SCALING-UP
Number of Partners/ Name of Key Institution(s)	EEA, IVM, Ecologic, FEEM
Countries Involved	
Contact Person	Onno Kuik
Email	o.j.kuik@vu.nl
Website	http://www.eea.europa.eu/publications/scaling-up-ecosystem-benefits-a
Timeframe of Initiative	2008-2010
Steps in Assessment Process	Stastical (meta) analysis on primary valuation studies; GIS analysis land use and cover; Mapping meta-function on study biomes
Approaches Used	Meta-analysis; GIS
Data sources	Corine land cover maps; Primary valuation studies
Main Ecosystems Addressed	Wetlands
Categorisation of ES	TEEB
Main Ecosystem Services Addressed	Provisioning/regulating/cutural
Scale of Analysis	Europe
Scale of Aggregation	Flexible
Number of Case Studies	1 (Wetlands)
Objectives	The objective is to use existing data on the economic value of ecosystem services for large-scale assessments through *value transfer*, taking into account the location, size, scarcity, and other attributes of the individual ecosystem sites, the proximity of residential areas, and the purchasing power of (potential) users or other beneficiaries of the ecosystems.
Results	Methodology and case study on European wetlands have been published in EEA report (http://www.eea.europa.eu/publications/scaling-up-ecosystem-benefits-a) and in Environmental and Resource Economics, (http://dx.doi.org/10.1007/s10640-011-9535-1)
Key strengths	Transparent scaling-up methodology taking account of supply and demand of ES
Key limitations	Does not take account of ecosystem quality; dependent upon quality of original studies; potentially large 'transfer' errors

	ILTER - SEA
Name of Initiative	ILTER - SEA

Number of Partners/ Name of Key Institution(s)	LTER networks
Countries Involved	NA
Contact Person	Terry Parr (UK Environmental Change Network)
Email	twp@ceh.ac.uk
Website	http://www.ilternet.edu/research/ecosystem-services-assessment
Timeframe of Initiative	
Steps in Assessment Process	1.Implementation of the Integrative Science for Society and the Environment" ISSE framework for each study site. Each member network will choose a site representing one of the biomes used for the Millennium Assessment (Table 1, see end of document) 2.Identification of six critical ES at each site, direction of change, primary drivers of change, public awareness of the ES, and institution(s) that manage the ES. 3.Identification of threshold interactions between environmental and socio-economic dynamics at multiple scales, and forecasting the effects of these interactions on ecosystem services and ecological resilience. 4.Synthesis within and among biomes of culture-specific socio-economic dynamics leading to increases or decreases in resilience.
Approaches Used	site-specific feedback models
Data sources	
Main Ecosystems Addressed	all MA biomes covered
Categorisation of ES	
Main Ecosystem Services Addressed	habitat/provisioning/regulating/cultural
Scale of Analysis	
Scale of Aggregation	
Number of Case Studies	
Objectives	Mission: to improve understanding of global ecosystems and inform solutions to current and future environmental problems. ILTER's ten-year goals are to: 1.Foster and promote collaboration and coordination among ecological researchers and research networks at local, regional and global scales 2.Improve comparability of long-term ecological data from sites around the world, and facilitate exchange and preservation of this data 3.Deliver scientific information to scientists, policymakers, and the public and develop best ecosystem management practices to meet the needs of decision-makers at multiple levels 4.Facilitate education of the next generation of long-term scientists.
Results	

Key strengths	
Key limitations	No focus on valuation

	JRC Atlas of ES
Name of Initiative	A European assessment of the provision of ecosystem services: Towards an atlas of ecosystem services
Number of Partners/ Name of Key Institution(s)	JRC
Countries Involved	EU
Contact Person	Joachim Maes, JRC
Email	joachim.maes@jrc.ec.europa.eu
Website	http://ies.jrc.ec.europa.eu/
Timeframe of Initiative	2010-2011
Steps in Assessment Process	Biophysical modelling (land use maps and quantified indicators for the provision/supply of ES); No monetary valuation; Tradeoff analysis between ES
Approaches Used	Mapping of land use and indicator variables; Principal Components Analysis for trade-offs between ES
Data sources	Multiple spatial data sets for EU
Main Ecosystems Addressed	Terrestrial biomes in the EU
Categorisation of ES	TEEB ES categorisation
Main Ecosystem Services Addressed	Provisioning, regulating and recreation. Focus is on provisioning and regulating.
Scale of Analysis	EU. Scale varies with ES depending on data. Trade-off analysis is at NUTS3 level
Scale of Aggregation	EU NUTS3
Number of Case Studies	Multiple case studies for different ES
Objectives	To establish a methodology for ecosystem service mapping; To summarize the key resources needed for this mapping exercise; To map the provision of ecosystem services at EU scale; To assess synergies and trade-offs of ecosystem services at EU scale; To estimate the contribution of European ecosystems to the provision of ecosystem services
Results	Mapping of indicators for a broad range of ES
Key strengths	Collection and use of spatial data sets for the EU. Development and application of indicators of potential ES supply
Key limitations	The indicators focus on the potential supply of ES but not on the demand or actual use. No monetary valuation (the term valuation is used to describe standardised scores for ES)

	MA SUBGLOBAL ASSESSMENTS
Name of Initiative	
Number of Partners/ Name of Key Institution(s)	WWF Russia, University of the West Indies, World Agroforestry Centre, Norwegian Institute for Nature Research, University of Alasca etc
Countries Involved	Canada, China, Chile, Vietnam, Trinidad, Sweden, South Africa, Portugal, the Philippines, Peru, Papua New-Guinea, Norway, India, Costa Rica
Contact Person	Cristian Samper
Email	Samper.Cristian@nmnh.si.edu
Website	http://www.maweb.org/en/Multiscale.aspx
Timeframe of Initiative	2005-
Steps in Assessment Process	Similar to the MA but aim is to assess differences in the importance of ecosystem services for human well-being around the world
Approaches Used	The subglobal assessments responded to three broad categories of need for an assessment: (1) summary and synthesis of information on complex issues to support decision-making; (2) strengthening the capacity of the users to assess and manage their resources or to participate in resource management; (3) research to address gaps in knowledge for resource management.
Data sources	
Main Ecosystems Addressed	multiple (forests, inland water, drylands, mountains, coastal, marine, islands)
Categorisation of ES	MA
Main Ecosystem Services Addressed	habitat/provisioning/regulating/cultural
Scale of Analysis	regional, sub-regional, local
Scale of Aggregation	
Number of Case Studies	more than 30 studies (approved and associated assgnments)
Objectives	The MA sub-global assessments were designed to meet needs of decision-makers at the scale at which they are undertaken, strengthen the global findings with on-the-ground reality, and strengthen the local findings with global perspectives, data, and models
Results	The MA subglobal working group produces a synthesis report of the findings of the various sub-global assessments and a resource on the lessons learned through the process on multiscale assessment methodologies, cross-scale interactions, and the incorporation of traditional and local knowledge into a scientific assessment process
Key strengths	local institutions involved, comparison of different spatial scales, allows to meet the information needs of decision-makers at multiple scales
Key limitations	

	Millenium Ecosystem Assessment
Name of Initiative	Millenium Ecosystem Assessment
Number of Partners/ Name of Key Institution(s)	UN, UNEP, UNDP, CGIAR, CMS, CBD, FAO, GEF, ICSU, UNCCD, UNFCCC, UNESCO, WORLD BANK, IUCN, WHO
Countries Involved	multiple
Contact Person	A.H. Zakri (United Nations University)
Email	zakri @ias.unu.edu
Website	http://www.maweb.org/en/index.aspx
Timeframe of Initiative	2001-2005
Steps in Assessment Process	The MA was undertaken by an international network of scientists and other experts, with a process modeled on the IPCC. More than 1300 authors from 95 countries were involved in the MA, organized into 4 working groups (Condition & Trends; Scenarios; Responses; Sub-global level).
Approaches Used	The MA was designed as an integrated assessment to cut across sectors, involving natural science and social science perspectives. The MA did not conduct new research, but it is the first assessment to focus on the impacts of ecosystem changes for human well-being. As with the IPCC, the MA primarily synthesized the findings of existing research, to make them available in a form that is relevant to current policy questions.
Data sources	The MA synthesized information from the scientific literature, data sets, and scientific models, and included knowledge held by the private sector, practitioners, local communities and indigenous peoples. Among the sub-global assessments, however, particularly those at local scales, the lack of data and literature did lead some sub-global assessment to undertake some new research and data collection.
Main Ecosystems Addressed	Both land and aquatic
Categorisation of ES	MA
Main Ecosystem Services Addressed	Provisioning, Habitat/Supporting, Regulating, Cultural
Scale of Analysis	The MA was a multi-scale assessment, which included component assessments undertaken at multiple spatial scales – global, sub-global, regional, national, basin and local levels.
Scale of Aggregation	multi-scale
Number of Case Studies	Although focus on world's ecosystems, chapters often zoom in at particular case studies
Objectives	The overall aims of the MA were to contribute to improved decision-making concerning ecosystem management and human well-being, and to build capacity for scientific assessments of this kind.
Results	Three aspects of the MA do represent important new contributions. -First, the findings of this assessment are the consensus view of the largest

	body of social and natural scientists ever assembled to assess knowledge in this area. -Second, the focus of this assessment on ecosystem services and their link to human well-being and development needs is unique. By examining the environment through the framework of ecosystem services, it becomes much easier to identify how changes in ecosystems influence human well-being and to provide information in a form that decision-makers can weigh alongside other social and economic information. -Third, the assessment identified a number of 'emergent' findings, conclusions that can only be reached when a large body of existing information is examined together. Four of these stand out: o The balance sheet. Although individual ecosystem services have been assessed previously, the finding that 60% of a group of 24 ecosystem services examined by the MA are being degraded is the first comprehensive audit of the status of Earth's natural capital. o Nonlinear changes. The MA is the first assessment to conclude that ecosystem changes are increasing the likelihood of nonlinear changes in ecosystems and the first to note the important consequences of this finding for human well-being. o Drylands. Because the assessment focuses on the linkages between ecosystems and human well-being, a somewhat different set of priorities emerge from it. While the MA does confirm that major problems exist with tropical forests and coral reefs, from the standpoint of linkages between ecosystems and people, the most significant challenges involve dryland ecosystems. o Nutrient loading. The MA confirms the emphasis that decision-makers are already giving to addressing important drivers of ecosystem change such as climate change and habitat loss. But the MA finds that excessive nutrient loading of ecosystems is one of the major drivers today and will grow significantly worse in the coming decades unless action is taken.
Key strengths	The MA had an innovative governance structure that was representative of not only scientists and experts, but also UN conventions, civil society groups, and indigenous peoples.
Key limitations	limited new research, costly exercise (US$24 million), thin on economic valuation

	Natura2000 Assessment
Name of Initiative	Natura2000 Assessment
Number of Partners/ Name of Key Institution(s)	
Countries Involved	EU

Contact Person	Ton Ijlstra (for the Netherlands)
Email	a.h.ijlstra@minlnv.nl
Website	http://www.natura.org/
Timeframe of Initiative	1992-
Steps in Assessment Process	
Approaches Used	member states submit data, which are validated by the European Topic Centre for Biological Diversity
Data sources	member states' data
Main Ecosystems Addressed	marine and terrestrial
Categorisation of ES	
Main Ecosystem Services Addressed	Habitat/Supporting
Scale of Analysis	detailed
Scale of Aggregation	EU
Number of Case Studies	NA
Objectives	Establishment of Special Protection Areas (birds) and Special Areas of Conservation (other animals)
Results	Natura2000 is protecting almost 20% of EU's land.
Key strengths	a wide ecological network protecting almost 20% of EU land
Key limitations	exclusive focus on conservation; no valuation

	Natural Capital Project
Name of Initiative	Natural Capital Project - Integrated Valuation of Environmental Services and Tradeoffs (InVest)
Number of Partners/ Name of Key Institution(s)	WWF, TNC, Stanford University, University of Minnesota
Countries Involved	Global
Contact Person	Emily McKenzie
Email	Emily.McKenzie@wwfus.org
Website	www.naturalcapitalproject.org
Timeframe of Initiative	2006-
Steps in Assessment Process	Biophysical modelling of provision of ES (production functions); Value transfer
Approaches Used	Spatial models (platform in ArcGIS)
Data sources	Multiple. New applications require gathering local data
Main Ecosystems Addressed	Terrestrial and marine
Categorisation of ES	MA

Main Ecosystem Services Addressed	All - but models not currently available for: groundwater recharge; agricultural production; flood risk; recreation; fisheries; carbon sequestration
Scale of Analysis	Global to sub-watershed
Scale of Aggregation	All
Number of Case Studies	8
Objectives	To develop tools for quantifying the values of natural capital in clear, credible and practical ways
Results	The development and application of the software tool InVEST, which enables decision-makers to quantify the importance of natural capital, to assess the tradeoffs associated with alternative choices, and to integrate conservation and human development.
Key strengths	Biophysical and spatially explicit modelling of ES (mainly regulating ES). Flexible GIS platform
Key limitations	GIS software, expertise and data required. Expert inputs at all steps to validate models

	PEER
Name of Initiative	Partnership for European Environmental Research (PEER)
Number of Partners/ Name of Key Institution(s)	7: Alterra, CEH, IRSTEA, JRC-IES, NERI, SYKE, UFZ
Countries Involved	UK, the Netherlands, Finland, France, Italy, Germany, Denmark
Contact Person	Markku Puupponen (SYKE)
Email	secretary@peer.eu
Website	http://www.peer.eu/
Timeframe of Initiative	2001-
Steps in Assessment Process	Several projects funded integrating natural sciences, social sciences and engineering. PRESS is discussed earlier. Other projects focusing on ecosystem services are: **CarboEurope** (Quantifying the European carbon balance), **Euro-limpacs** (impact of climate change on European freshwater ecosystems)
Approaches Used	Experiments, field work, simulations. **CarboEurope**: Collection of ecosystem level data of carbon stock changes in biomass and soil and modelling of effects of driving forces on the Carbon Cycle such as land management, disturbance by harvest. **Euro-limpacs** considers the interactions of freshwater ecosystems with climate change at three critical time scales: hours/days (concerned with changes in the magnitude and frequency of extreme events), seasons (concerned with changes in ecosystem function and life-cycle strategies of freshwater biota) and years/decades (concerned with ecological response to environmental pressure, including stress reduction and ecosystem recovery).

Data sources	AWMN data + primary data.
Main Ecosystems Addressed	Forests, lowland agriculture, freshwater ecosystems
Categorisation of ES	
Main Ecosystem Services Addressed	Regulating, Provisioning, Habitat/Supporting
Scale of Analysis	Europe (regional and aggregate data)
Scale of Aggregation	
Number of Case Studies	13 Flagship projects: http://www.peer.eu/projects/peer-flagship-projects/
Objectives	Mission is: a. to build a strategic partnership of major European public environmental research centres; b. to lead a European Research Area that strengthens the knowledge base for the sustainable development of a changing world; and c. to foster innovative interdisciplinary research and cross-cutting approaches in support of national and European policy-makers, industry and society.
Results	Several research projects, training courses and publications.
Key strengths	Focus on multiple time and spatial scales. Multidisciplinary approaches.
Key limitations	Thin on valuation

	RUBICODE
Name of Initiative	RUBICODE
Number of Partners/ Name of Key Institution(s)	University of Oxford, Alterra Wageningen, Lund University, University of the Aegean, University of Tartu etc
Countries Involved	UK, the Netherlands, Spain, Belgium, Sweden, Greece, Slovakia, Portugal, France, Austria, Estonia, Hungary, South Africa, Argentina, Australia, New Zealand, Romania
Contact Person	Paula Harrison
Email	PAHarriso@aol.com
Website	http://www.rubicode.net/rubicode/index.html
Timeframe of Initiative	2006-2009
Steps in Assessment Process	To develop and apply concepts of dynamic ecosystems and the services they provide, covering both terrestrial and freshwater ecosystems in a comprehensive framework. To explore relationships between service-providing populations, ecosystem resilience, function and health, and socio-economic and environmental drivers of biodiversity change. To improve and test indicators that provide rapid assessment methods for monitoring ecosystem and habitat ecological quality.To develop habitat management strategies that take account of drivers of biodiversity change in order to maintain threatened populations or assist populations to adapt. To organise workshops to evaluate the concepts

	and methods, raise awareness and identify gaps in knowledge. To synthesize knowledge from the reviews and workshops, and further develop various concepts, frameworks or strategies to address gaps in knowledge and inform future research needs. To develop and apply concepts of dynamic ecosystems and the services they provide, covering both terrestrial and freshwater ecosystems in a comprehensive framework. To explore relationships between service-providing populations, ecosystem resilience, function and health, and socio-economic and environmental drivers of biodiversity change. To improve and test indicators that provide rapid assessment methods for monitoring ecosystem and habitat ecological quality.To develop habitat management strategies that take account of drivers of biodiversity change in order to maintain threatened populations or assist populations to adapt. To organise workshops to evaluate the concepts and methods, raise awareness and identify gaps in knowledge. To synthesize knowledge from the reviews and workshops, and further develop various concepts, frameworks or strategies to address gaps in knowledge and inform future research needs.
Approaches Used	calculation of services in terms of Service Providing Units (SPUs); integrated ecology-economy modelling; dynamic bioeconomic modelling
Data sources	terrestrial, freshwater ecosystems
Main Ecosystems Addressed	agriculture, forests, grasslands, mountains, heathlands, rivers/lakes
Categorisation of ES	MA
Main Ecosystem Services Addressed	habitat/provisioning/regulating/cultural
Scale of Analysis	
Scale of Aggregation	
Number of Case Studies	
Objectives	The development of flexible and effective conservation strategies and their implementation will be essential in order to halt the loss of biodiversity. These should concentrate on managing dynamic ecosystems for maintaining their capacity to undergo disturbance, while retaining their functions, services and control mechanisms (ecological resilience).
Results	The most recent European trends in human use of ecosystem services showed increases in demand for crops, timber, water flow regulation, recreation and ecotourism, but decreases in livestock production, freshwater capture fisheries, wild foods and virtually all services associated with ecosystems which have considerably decreased in area (e.g. semi-natural grasslands). The value of assessing the impact of environmental or management changes

	on ecosystem service provision in terms of species traits rather than taxonomic identity was investigated. A framework was developed which assumes impacts will be strongest if there are linkages between traits that determine response to change and traits that provide the ecosystem service. The Framework for Ecosystem Service Provision (FESP) was developed to assess the impacts of environmental change drivers on ecosystem services and identify the mechanisms of either mitigation or adaptation that would derive from policy and management responses. The framework enables evaluation of conflicts and trade-offs between not only multiple ecosystem services, but also multiple service beneficiaries. It covers ecosystem services dependent on multiple trophic levels, and has been populated with examples from the literature.
Key strengths	wide range of ecosystem services
Key limitations	thin on valuation (only secondary data)

	SCALES
Name of Initiative	SCALES
Number of Partners/ Name of Key Institution(s)	UFZ, University of the Aegean, University of Reading, University of Leeds etc
Countries Involved	Germany, Greece, UK, Czech Republic, France, Poland, Sweden, Finland, Bulgaria, Estonia, Switzerland, Portugal, Australia, Slovenia, Cyprus, Lithuania, Taiwan, Norway
Contact Person	Klaus Henle
Email	klaus.henle@ufz.de
Website	http://www.scales-project.net/
Timeframe of Initiative	2009-2014
Steps in Assessment Process	1) Assess and model the socio-economic driving forces and resulting environmental pressures (habitat loss and fragmentation, changing climate, disturbance) affecting European across scales. 2) Analyse the scale-dependent impacts of these pressures on components of biodiversity ranging from genes to species' populations to biotic communities and ecosystems; 3) Develop and evaluate new methods for upscaling and downscaling to facilitate the provision of environmental, ecological, and socio-economic information at relevant and matching scales. 4) Assess the effectiveness and efficiency of policy instruments and identify innovative policy instruments to address scale-related conservation problems; improve multilevel biodiversity governance; 5) Evaluate the practical suitability and matching of methods and policy instruments to deliver effective European biodiversity conservation across

	scales, using networks of protected areas, regional connectivity, and monitoring of status and trend of biodiversity as a common testing ground; 6) Translate the results into policy and management recommendations and integrate them in a web based support tool kit (SCALETOOL) to support sustainable conservation action across scales. 7) Disseminate the results to policy makers, biodiversity managers, scientists, and the general public.
Approaches Used	case-study analyses, historical data on biodiversity and human interactions and development of future projections
Data sources	
Main Ecosystems Addressed	birds, amphibians, reptiles, butterflies, carabid beetles, bees, wasps, and vascular plants
Categorisation of ES	
Main Ecosystem Services Addressed	habitat
Scale of Analysis	
Scale of Aggregation	
Number of Case Studies	
Objectives	SCALES aims to provide the scientific and policy research needed to guide scale-dependent management actions by advancing and integrating our understanding of natural and anthropogenic processes and their effects upon biodiversity at different scales
Results	
Key strengths	dyamic analysis over space and time
Key limitations	no focus on valuation

	TEEB QA
Name of Initiative	TEEB – Quantitative Assessment
Number of Partners/ Name of Key Institution(s)	SAC, IVM, PBL, Wageningen, DEFRA, EC DG-ENV, UNEP
Countries Involved	Global analysis
Contact Person	Salman Hussein, SAC
Email	salman.hussain@sac.ac.uk
Website	NA
Timeframe of Initiative	2010-2011
Steps in Assessment Process	Biophysical modelling (land use change and habitat quality); Valuation of change in ecosystem service provision; Policy appraisal
Approaches Used	Integrated Assessment Model of land use and biodiversity change; Meta-

	analytic spatially explicit value transfer; Cost-benefit analysis
Data sources	GLC2000 land use data; Ecosystem Services Partnership (ESP) value database
Main Ecosystems Addressed	Temperate forest, tropical forest, grasslands, wetlands, mangroves, coral reefs, fresh water systems
Categorisation of ES	TEEB ES categorisation
Main Ecosystem Services Addressed	All (but constrained by availability of value estimates in literature)
Scale of Analysis	Biophysical model – 50 km grid cells; Valuation – ecosystem patches with minimum size of 1km grid cell
Scale of Aggregation	Global and OECD regions
Number of Case Studies	Six biomes
Objectives	Global evaluation of broad policy options for biodiversity conservation
Results	Cost-Benefit Analysis of selected set of broad policy opitons for biodiversity conservation on a global scale. Development of meta-analytic value functions for six main biomes.
Key strengths	Spatially explicit variation in ES values
Key limitations	Valuation does not reflect variation in ecosystem quality

	UK Biodiversity Action Plan
Name of Initiative	UK Biodiversity Action Plan
Number of Partners/ Name of Key Institution(s)	UK Government
Countries Involved	UK
Contact Person	John Robbs (DEFRA)
Email	
Website	www.jncc.defra.gov.uk/page-5155
Timeframe of Initiative	1994- (several reports produced individually by England, Northern Ireland, Scotland and Wales since the devolution of power in the late 1990s)
Steps in Assessment Process	Expert Working Groups identify priority species and habitats based on: a. international importance, b. rate of decline and c. risk. The list informs statutory lists of priorities in the four UK countries (England, Scotland, Wales, Northern Ireland)
Approaches Used	Multicriteria Analysis (quantitative and qualitative data).
Data sources	NBN Gateway, 9 Expert Groups
Main Ecosystems Addressed	Terrestrial and Freshwater Habitats (rivers, grasslands, lakes, temperate woodlands, swamps, heathland), Marine Habitats, Species
Categorisation of ES	
Main Ecosystem Services Addressed	Only Habitat/Supporting Services
Scale of Analysis	Not specified but at the very macro level

Scale of Aggregation	UK (England, Scotland, Wales, Northern Ireland)
Number of Case Studies	NA
Objectives	The UK BAP aims to describe the biological resources of the UK and provide detailed plans for conservation of these resources, at national and devolved levels. Action plans for the most threatened species and habitats have been set out to aid recovery, and reporting rounds every three- to five-years show how the UK BAP has contributed to the UK's progress towards the significant reduction of biodiversity loss
Results	In the 1990s, 436 action plans were generated as a result of the UK BAP. Plan leaders were asked to report against targets such as status, trends, knowledge, progress, threats, and constraints. There have been four reporting rounds, the first in 1999, and the most recent in 2008. The UK BAP priority list now contains 1150 species, and 65 habitats.
Key strengths	Long-term assessment (changes over a 25 year period)
Key limitations	Focus on Conservation of Ecosystems but not Ecosystem Services, No Valuation of Ecosystems and Services

	US ENVIRONMENTAL PROTECTION AGENCY
Name of Initiative	
Number of Partners/ Name of Key Institution(s)	US Environmental Protection Agency
Countries Involved	US
Contact Person	Rick Linthurst
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Website	http://www.epa.gov/ecology/
Timeframe of Initiative	
Steps in Assessment Process	The Ecosystem Services Research Program of the US EPA is designed to to improve our understanding, and promote the protection of ecosystem services at multiple scales and complexity. Planned research outcomes: A. New decision support systems and an on-line decision support platform that assists decision makers in using existing and emerging Ecosystem Services Research Program methods, models, and tools, and allows users to explore the outcomes of alternative management options. B. A national atlas of ecosystem services, and a design for inventorying those services to define location, condition and value. C. A better set of tools, methods, and models for understanding pollutant impacts on ecosystem services using a key example — nitrogen. D. A better set of tools, methods, and models for understanding the effects of multiple stresses on ecosystem services using a key ecosystem type — wetlands. E. Four place-based examples where local

	communities incorporate ecosystem services into their decision-making to illustrate the long term benefits of this perspective, applied in very different socio-political, geographic, and ecological environments. Studies are planned in: Tampa Bay Region on the Gulf Coast of Florida, The Willamette River Basin in central Oregon, The Midwestern US, and The Coastal Carolinas
Approaches Used	development of indicators for condition of ecosystems; mapping; ecological risk assessment; development of decision-support tools
Data sources	multiple (both primary and secondary)
Main Ecosystems Addressed	coastal, river, lakes, terrestrial
Categorisation of ES	MA
Main Ecosystem Services Addressed	mainly habitat/provisioning/regulating
Scale of Analysis	(US) multiple, depends on the study
Scale of Aggregation	
Number of Case Studies	NA
Objectives	EPA's ecosystems research is working to protect ecosystems and the air and water resources that provide numerous benefits for humans and other living things.
Results	Several advancements in the fields of: Water and Climate, Ecosystems and Air Quality, Watershed Protection, Nutrients Management, Ecological Risk Assessment. Researchers are developing sophisticated models and tools that are used to protect ecosystems and ecosystem services across the nation (e.g. National Atlas for Sustainability, National Ecosystem Goods and Services Classification System)
Key strengths	focus on local communities and participation; multidiciplinary research
Key limitations	limited on valuation

	US NATIONAL RESEARCH COUNCIL
Name of Initiative	
Number of Partners/ Name of Key Institution(s)	US NRC and several US academic institutions
Countries Involved	US
Contact Person	Mark Gibson; Ellen De Guzman; Geoffrey Heal
Email	gmh1@columbia.edu; edguzman@nas.edu
Website	http://dels.nas.edu; http://www.nap.edu/
Timeframe of Initiative	
Steps in Assessment Process	Several reports on ecosystem services with multiple approaches: e.g. the 2012 report "Ecosystem Services: Charting a Path to Sustainability" focusses on -how ecosystem services affect infectious and chronic diseases

	-how to identify what resources can be produced renewably or recovered by developing intense technologies that can be applied on a massive scale -how to develop social and technical capabilities to respond to abrupt changes in ecosystem services -how to design agricultural and aquacultural systems that provide food security while maintaining the full set of ecosystem services needed from landscapes and seascapes -how to design production systems for ecosystem services that improve human outcomes related to food and nutrition -how to develop appropriate methods to accurately value natural capital and ecosystem services -how to design a federal policy to maintain or improve natural capital and ecosystem services within the United States, including measuring and documenting the effectiveness of the policy -how to design a system for international trade that accounts for impacts on ecosystem services -how to develop a program that increases the American public's appreciation of the basic principles of ecosystem services Charting a Path to Sustainability Charting a Path to Sustainability
Approaches Used	multiple (e.g. travel cost, stated preferences, production function etc)
Data sources	mainly secondary sources
Main Ecosystems Addressed	both aquatic and terrestrial
Categorisation of ES	
Main Ecosystem Services Addressed	habitat/provisioning/regulating/cultural
Scale of Analysis	US regions
Scale of Aggregation	
Number of Case Studies	NA
Objectives	
Results	
Key strengths	explicit focus on valuation - e.g. see the report "Valuing Ecosystem Services: Toward Better Environmental Decision-Making" in 2004
Key limitations	provision of export reports but not necessarily primary research

	Valuing Nature Network
Name of Initiative	Valuing Nature Network
Number of Partners/ Name of Key Institution(s)	University of East Anglia, University of Cambridge, University of Nottingham, Imperial College London, University of York
Countries Involved	Uk (management) although members come from several countries
Contact Person	Ian Bateman (UEA)
Email	i.bateman@uea.ac.uk
Website	http://www.valuing-nature.net/
Timeframe of Initiative	2010-
Steps in Assessment Process	Network of experts in valuation of ecosystem services, Affiliated 10 projects, Research clusters/workshops
Approaches Used	Participatory Monitoring, Well-Being Measurements, Statistical model , General equilibrium model, Case study analyses
Data sources	Primary qualitative data on communities' perceptions, marine indicators, socio-economic/demographic data, literature reviews
Main Ecosystems Addressed	Marine habitats, Fresh water habitats, peetlands, lowland agriculture
Categorisation of ES	
Main Ecosystem Services Addressed	Provisioning, Habitat/Supporting, Regulating, Cultural
Scale of Analysis	Not specified
Scale of Aggregation	UK (England, Scotland, Wales, Northern Ireland)
Number of Case Studies	although not case-study based, there are 10 affiliated projects: http://www.valuing-nature.net/related-projects
Objectives	The Valuing Nature Network's mission is to support interdisciplinary partnerships to scope, develop and promote research capacity in the valuation of biodiversity, ecosystem services and natural resources and facilitate the integration of such approaches in policy and practice in the public and private sectors.
Results	Expanding netweork with more than 150 members and 10 affiliated projects
Key strengths	Emphasis on linking research with policy-makers, interdisciplinarity
Key limitations	Projects of short duration and fragmented from one another.

	VOLANTE
Name of Initiative	VOLANTE
Number of Partners/ Name of Key Institution(s)	ALTERRA, Edinburgh University, VU, Copenhagen University etc
Countries Involved	10 countries (Netherlands, UK, Greece, Austria, Germany, Denmark, Finland,

	France, Romania, Belgium)
Contact Person	Sandra Lavorel
Email	sandra.lavorel@ujf-grenoble.fr
Website	http://www.volante-project.eu/
Timeframe of Initiative	2010-2014
Steps in Assessment Process	improving understanding of the Processes underpinning land use change, the refinement of Assessment tools, and the development of policy relevant Visions that help in the identification of sustainable development pathways.
Approaches Used	linking bottom-up and top-down land change models, developing human behavioural models
Data sources	CORINE, IACS, LANDSAT TM/ETM etc
Main Ecosystems Addressed	terrestrial (wetlands, agricultural land, rivers)
Categorisation of ES	
Main Ecosystem Services Addressed	habitat/provisioning/regulating
Scale of Analysis	7 european case studies
Scale of Aggregation	EU member state
Number of Case Studies	7: e.g. Roskilde municipality, Reichraming municipality, Stancuta, Lesvos etc
Objectives	The overall project aim is to inform European policy and land management about the bandwidth of critical pathways for multifunctional and sustainable land use.
Results	So far WP2 has produced a literature review on land use and landscape change
Key strengths	active involvement of stakeholders
Key limitations	

Annex 3. Linking accounting approaches and valuation methods to policy applications

Accounting Approach	Application	Positive/Negatives of approach	Example of user
Structured national environmental accounts including comprehensive valuation of ecosystem services	Reporting: Provides a broader perspective on national wealth. Supports indicators to monitor and report on changes in ecosystem services to compare to in economic indicators. Supports assessment of sustainability of resource use. Policy: Could inform national priority setting and scenario building	+ Coherent with System of National Accounts - Feasibility still under study - Difficult to obtain consensus on methods - Lack of data requires estimation	SEEA, UK NEA (to some extent), MEGS
Structured national environmental accounts focusing on estimation costs of ecosystem (analogous to consumption of fixed capital)	Policy: Measurement of the ecological debt and adjustment of Net Domestic Product, National Income and Final Consumption	+ Entirely compatible with SNA concepts - Less amendable to local applications - Not necessarily consistent with economic theory	EEA
Green accounting (in principle includes structured national environmental accounts above)	Currently applied largely to local problem solving using various methodologies	+ Encourages awareness of value of ecosystem services - No specific methodology or structured account	Pavan Sukhdev personal communication) TEEB
Total Economic Value (TEV)	Largely for awareness purposes. Used to characterize the contribution that EGS make to society's general well-being	+ Provides abroad scope of all values - May encourage double counting if added without elimination of overlaps	TEEB
Pseudo-markets	Reverse auctions where landowners offer to maintain a specified level of ecosystem services. This establishes a supply curve	+ Works for local areas to allocate conservation funds - No demand curve since demand is limited to funds available - Difficult to scale to national level	Victoria Australia, Manitoba, Canada
Nature index, common currency, ecosystem health	Biophysical indicators to monitor changes in ecosystem quality or health. Can be used in conjunction with economic indicators to assess sustainability of economic activities	+ Does not require monetary valuation of ecosystem services - Subjective weighting of underlying indicators to allow aggregation	Norway, Australia, Rapport
UK NEA (uses various methods)	Assess scenarios; impact on EGS values of different development	+ Adjusts EGS values to net out the contribution	UK NEA

	paths	of human inputs to final goods and services	
Valuation Method	**Application**	**Positive/Negatives of the approach**	**Example of user**
Primary studies (using many methods but applied at local scale)	Biophysical measures and local estimation of values good for local decision making	+ Best approach for local area - Difficult to scale up to regional or national level - Often focused on one local issue rather than establishing comprehensive account	EVRI (Environmental Valuation Research Inventory)
Site-specific benefits transfer	Attributing values to a 'policy site' based on values determined in the past for a 'study side'. This can augment or substitute for a primary study. As with primary studies can inform local decision making about alternative land uses	+ Can provide reasonable estimates if demand function is properly estimated - Study areas need to have similar biophysical and socio-economic characteristics	Various practioneers: Ruitenbeek, Wilson and Hoehn
Meta-analysis and benefits transfer to develop comprehensive valuation	Global, national, regional awareness building, communications and priority setting	+ Relatively simple methodology - Criticism of large-scale benefits transfer without accounting for socio-economic context[15] - Underlying studies generally not sufficiently documented	Costanza, Ontario
Production function (PF)	Assess ecosystem services as 'natural subsidy' to economic production. Best for integrating with existing production (agriculture, forestry, fisheries) policy modeling	+ Compatible with Computable General Equilibrium Modeling - Only addresses inputs to economic production	DSS (2010), Ian Bateman
Willingness to pay, willingness to accept, choice modeling surveys	Used for establishing a pseudo price for ecosystem services when markets don't exist. Appropriate for priorization between different development alternatives	+ Well-established methodology - Often requires comparison or aggregation of market with non-market (consumer surplus) prices	Adamowics, EVRI, Ducks Unlimited, RIASs

Note: The listing of approaches is a freeform for the current draft. Certain approaches are included within others or overlap with others. They are named as commonly discussed. It would be beneficial to develop this into a more rigorous taxonomy.

Source : Adapted from Wang et al. (2012)

[15] This criticism is valid for Costanza-type meta-analysis, recent applications take socio-economic context into account.

Annex 4. Survey of participants at the TEEB Conference 2012

TEEB CONFERENCE PARTICIPANT QUESTIONNAIRE

Thank you for taking the time to complete this short questionnaire. The survey is conducted by the Institute for Environmental Studies of the VU University Amsterdam in collaboration with the TEEB conference organizers UFZ. The survey results will be used to inform the European Commission. Results will be made available on the TEEB website approximately 2 months after the conference. The questionnaire should take approximately 5 minutes to complete.

1. What is your academic background?

☐ I have a degree in Social Sciences, namely …………………

☐ I have a degree in Natural Sciences, namely ………..……….

☐ Other, namely ……………………

2. In what type of organization do you work?

☐ Government

☐ University

☐ Independent research institute

☐ Other non-government organization (NGO)

☐ Private sector

☐ Other, namely …………………………..

3. **In which country do you work?** (if your work covers multiple countries, regions or international levels (e.g. EU, UN) please specify the region)

   ………………………………………….

4. **Were you, or are you currently, involved in any national or international TEEB initiative(s)?**

☐ Yes

☐ No [SKIP NEXT QUESTION]

5. **Please specify which one(s)?**

   ……………………………………………..

6. **How much progress has in your opinion been made in the following fields since the start of TEEB?**

	No progress at all	Some progress	A lot of progress
1. Establishing links between biodiversity and ecosystem services	☐	☐	☐
2. Development of a common framework for economic analysis of biodiversity and ecosystem services	☐	☐	☐
3. Biodiversity and ecosystem services quantification	☐	☐	☐
4. Biodiversity and ecosystem services mapping	☐	☐	☐
5. Biodiversity and ecosystem services valuation	☐	☐	☐
6. Integration of biodiversity and ecosystem services in European policy and decision-making	☐	☐	☐
7. Integration of biodiversity and ecosystem services in national policy and decision-making	☐	☐	☐

7. Has to your knowledge any specific policy or policy instrument been developed and implemented towards the protection and enhancement of ecosystem services and biodiversity based on past or current TEEB initiatives?

☐ Yes

☐ No [SKIP NEXT QUESTION]

8. Can you specify which one?

……………………………………………..

9. Does there exist, in your opinion, an adequate <u>common</u> framework for the economic analysis of ecosystems and biodiversity in Europe or your country?

☐ Yes

☐ No [SKIP NEXT QUESTION]

10. Can you specify which one?

……………………………………………..

11. How important are in your view the following roles of economic valuation in managing biodiversity and ecosystem services?

	Not important at all	Somewhat important	Very important
1. Raising awareness	☐	☐	☐
2. Setting taxes and subsidies (market based instruments)	☐	☐	☐
3. Environmental liability and compensation	☐	☐	☐
4. Green accounting	☐	☐	☐
5. Improving cost-benefit analysis to support policy and decision-making	☐	☐	☐
6. Improving environmental justice and alleviate poverty related to ecosystem degradation	☐	☐	☐
7. Other, namely …………………………	☐	☐	☐

12. How important are, in your opinion, the following challenges of including the values of biodiversity and ecosystem services in national or EU level accounting frameworks?

	Not important at all	Somewhat important	Very important
1. Lack of understanding of ecosystem functioning and provision of services	☐	☐	☐
2. Lack of data on the spatial distribution of ecosystem services and biodiversity	☐	☐	☐
3. Lack of data on the values of ecosystem services and biodiversity	☐	☐	☐
4. Uncertainty associated with the precision of non-market valuation	☐	☐	☐
5. Inadequate linkage between biophysical and economic models	☐	☐	☐
6. Mismatch between the spatial scale of value data and the requirements for national level accounts	☐	☐	☐
7. Inflexible national accounting frameworks	☐	☐	☐
8. Financial and capacity constraints at the national level			
9. Limited priority given by policy-makers			
10. Other, please specify …………….			

13. Finally, what is in your view the most important future research priority for quantifying, mapping, valuing and accounting for ecosystem services and biodiversity at the national or EU level?

……………………………………………..

Thank you for your cooperation!

The results from this survey will be made available on

the TEEB website approximately 2 months after the conference

Annex 5. Online Survey of Identified Experts

Thank you for taking the time to complete this short questionnaire. It is conducted by the Institute for Environmental Studies (IVM) of the VU University Amsterdam to provide input to the DG Environment funded project "TEEB follow-up study for Europe". The questionnaire should take approximately **5-10 minutes to complete**.

The purpose of this questionnaire is to gather opinions on how to **achieve the EU 2020 Biodiversity Strategy** Target 2, Action 5:

"Improve knowledge of ecosystems and their services in the EU. Member States, with the assistance of the Commission, will **map and assess the state of ecosystems and their services** in their national territory by 2014, **assess the economic value of such services**, and promote **the integration of these values into accounting and reporting systems** at EU and national level by 2020."

The following questions ask your opinion on the challenges faced in each step in the ecosystem service (ES) assessment–valuation–accounting process.

1. What are the **most important challenges** to be addressed in **mapping and assessing the state of ecosystems and their services** at the national level? (1 = not important; 5 = very important)

	1	2	3	4	5
Lack of understanding of ecosystem functioning and provision of services					
Inadequate classification of ecosystem services					
Inadequate methods for mapping and assessing ES provision					
Lack of data on the spatial distribution/variation of ES					
Lack of data on ES provision at national scales					
Financial and capacity constraints at the national level					
Other, please specify ……………..					

2. What are the **most important challenges** to be addressed in **assessing the economic value of ecosystem services** at the national level? (1 = not important; 5 = very important)

	1	2	3	4	5
Inadequate linkage between biophysical and economic valuation approaches					
Lack of understanding of the values of ecosystem services					
Inadequate methods for valuing ES					
Lack of data on the spatial distribution/variation of ES values					
Lack of data on ES values at national scales					
Financial and capacity constraints at the national level					
Other, please specify ……………..					

3. What are the **most important challenges** to be addressed in **integrating ES values into accounting and reporting systems** at the national level? (1 = not important; 5 = very important)

	1	2	3	4	5
Lack of understanding of the linkage between ES and accounting principles					
Inadequate practical methods for including ES values in national accounts					
Value data not available at the spatial scale required for national accounting					
Value data does not meet the accuracy requirements for national accounting					
Financial and capacity constraints at the national level					
Other, please specify …………….					

4. What are the most important future research priorities for quantifying, mapping, valuing and accounting for ecosystem services at the national level? If you believe there are multiple research priorities, please list them in order of importance.

   1)……………………………………………..

   2)……………………………………………..

   3)……………………………………………..

   4)……………………………………………..

   5)……………………………………………..

5. In which country do you work?

   …………………………………………

6. For the country in which you work, please indicate the extent to which you agree with the following statements (1 = don't agree; 5 = completely agree)

	1	2	3	4	5
There is sufficient technical capacity to conduct ecosystem assessments					
ES values can be integrated into national accounting by 2014					
ES values can be integrated into national accounting by 2020					

Annex 6. Comparison of terminology

Table A1 provides a summary of the use of different terms related to ecosystem services by four key initiatives: the UK National Ecosystem Assessment (UK NEA), the European Environment Agency (EEA) Common International Classification of Ecosystem Services (CICES), the Mapping and Assessment of Ecosystems and their Services (MAES) working group, and the System of Environmental-Economic Accounting (SEEA) Experimental Ecosystem Accounts.

To a large extent, these different initiatives are closely aligned in their use of concepts. There are subtle differences that reflect differences in the focus of each initiative. To a large extent, these initiatives also use terminology in a broadly similar way. There are, however, some important differences in terminology that may generate misunderstanding of the intended meaning.

The term 'ecosystem services' is used consistently to describe the contributions of ecosystems to human well-being. In TEEB and the UK NEA terminology an important distinction is then made between 'final ecosystem services' (those that are used as inputs into the production of goods) and 'intermediate ecosystem services' (natural processes that contribute to the provision of final ecosystem services). The other initiatives effectively make the same distinction but simply use the term 'ecosystem service' narrowly to mean 'final ecosystem service', and use a variety of other terms to convey the concept of underlying ecosystem processes that support the provision of ecosystem services. These include: ecosystem processes, functions, supporting services, and intra- and inter-ecosystem flows.

The term 'ecosystem function' is used in two different ways. It is used to describe underlying ecosystem processes (i.e. as an equivalent to 'intermediate ecosystem services'). In the MAES analytical framework, following its definition in the MA and TEEB, it is also used to describe the capacity or potential of an ecosystem to deliver services, which may or may not be utilised.

The term 'good' is used in two distinct ways. The first usage of the term 'good' is the traditional meaning of a physical product that is used for consumption (often used in the phrase "goods and services"). The second usage of the term 'good', as used in the UK NEA, is to describe the object, product or service (i.e. it can be physical and non-physical) that is consumed by humans to generate welfare. The reasoning behind this usage of the term 'good' is to avoid duplicating the use of the word 'service' (i.e. "ecosystem service" and "goods and services").

The term 'benefit' is also used in two distinct ways. The first usage describes the goods that are produced using ecosystem services (see CICES and SEEA). In this case, the term 'benefit' is equivalent to the term ‘good’. The second usage of ‘benefit’ describes a positive change in human wellbeing that results from consuming a ‘good’ (see UK NEA and MAES).

Table A1 Comparison of terminology

	UK NEA	**EEA – CICES (V4.3)**	**MAES**	**SEEA Experimental Ecosystem Accounts**
Ecosystem services	Ecosystem services refer to those contributions of the natural world that are used to produce goods which people value	Ecosystem services are the contributions that ecosystems make to human well-being.	The benefits that people obtain from ecosystems (MA, 2005). The direct and indirect contributions of ecosystems to human wellbeing (TEEB, 2010). The concept 'ecosystem goods and services' is synonymous with ecosystem services. Ecosystem services are derived from ecosystem functions and represent the realised flow of services for which there is demand.	Ecosystem services are the contributions of ecosystems to benefits used in economic and other human activity. Ecosystem services are flows that connect ecosystems with well-being. Ecosystem services are generated by ecosystem assets through ecosystem processes that reflect the combination of ecosystem characteristics, intra-ecosystem flows and inter-ecosystem flows.
Ecosystem functions	Term not used	Term not used	The capacity or potential to deliver ecosystem services. Functions are constituted by different combinations of processes, traits and structures and represent the potential that ecosystems have to deliver services, irrespective whether or not they are used by humans	Not defined but examples given as: recycling of nutrients in an ecosystem, primary productivity. Examples of ecosystem processes are: photosynthesis, decomposition.

	UK NEA	EEA – CICES (V4.3)	MAES	SEEA Experimental Ecosystem Accounts
Final ecosystem services	Final ecosystem services are the last item in the chain of natural processes which provides inputs to the production of goods used by humans. Some final ES are inputs in the production of products which are then consumed whereas others are consumed directly (e.g. fresh air or local recreation)	Final ecosystem services are the contributions that ecosystems make to human well-being. These services are final in that they are the outputs of ecosystems (whether natural, semi-natural or highly modified) that most directly affect the well-being of people. A fundamental characteristic is that they retain a connection to the underlying ecosystem functions, processes and structures that generate them	Term is not used	The terms ecosystem service and final ecosystem service are equivalent
Intermediate ecosystem services	Intermediate ecosystem services are natural processes that contribute to other ecosystem functions, but do not directly input into the production of goods consumed by humans	Intermediate or supporting services (these terms are equivalent) are the underpinning ecological structures, processes and functions	Term not used. Note that the terms ecosystem processes and functions are used as equivalent	Intra- and inter- ecosystem flows that relate to on-going ecosystem processes, commonly referred to as supporting services, are not considered ecosystem services. They are, however, considered as part of the measurement of ecosystem assets

	UK NEA	EEA – CICES (V4.3)	MAES	SEEA Experimental Ecosystem Accounts
Goods	The term 'good' is applied to any object which generates human wellbeing. This includes both physical and non-physical (pure experiential, non-consumptive) objects. Note also that this definition of good embraces the economic definitions of both goods and economic services	Ecosystem goods and benefits are things that people create or derive from final ecosystem services. These final outputs from ecosystems have been turned into products or experiences that are not functionally connected to the systems from which they were derived. Goods and benefits can be referred to collectively as 'products'	Synonymous with ecosystem services (in the sense of "goods and services")	Used to describe physical products that are consumed (i.e. in the sense of "goods and services")
Benefits	Benefits are the value of welfare improvements	See 'goods'	Benefits are positive changes in human wellbeing from the fulfilment of our needs and wants	Benefits comprise of products produced by economic units (included in the System of National Accounts) and those that are not produced by economic units (not included in SNA).
Value	Value is the change in human wellbeing generated by a good	Not defined. A distinction is made between social and economic values in which social values include cultural significance as well as moral and aesthetic worth for people	Not defined. It is noted that not all values can be expressed in monetary terms (e.g. health, social, conservation). The transition from benefits to values is complex in the real world of appreciation by humans, depending on location, relative scarcity, time in life, or cultural background	Not defined but a distinction is made between the welfare economic concept of value (i.e. consumer and producer surplus) and the exchange concept of value (i.e. gross revenue of a market transaction) that is used in the SEEA.

	UK NEA	EEA – CICES (V4.3)	MAES	SEEA Experimental Ecosystem Accounts
Wellbeing	Wellbeing is a positive physical, social and mental state. It requires that basic needs are met, that individuals have a sense of purpose, that they feel able to achieve important personal goals and participate in society. It is enhanced by conditions that include good health, financial and personal security, rewarding employment, and a healthy and attractive environment	Human well-being is that which arises from adequate access to the basic materials for a good life needed to sustain freedom of choice and action, health, good social relations and security. The state of well-being is dependent on the aggregated output of ecosystem goods and benefits, the provision of which can change the status of well-being	A context and situation dependent state, comprising basic material for a good life, freedom and choice, health and bodily well-being, good social relations, security, peace of mind, and spiritual experience	Term not defined. The relationships between benefits and well-being are not the focus of the SEEA and are not articulated
Natural capital	Natural capital comprises both ecosystem and abiotic assets that have the potential to provide ecosystem services	Not yet explicitly defined	Natural capital includes ecosystem capital and sub-soil assets and abiotic flows.	Term not defined. Ecosystem assets are spatial areas containing a combination of biotic and abiotic components and other characteristics that function together. Ecosystem assets are measured from two perspectives: 1. in terms of ecosystem condition and extent; 2. in terms of ecosystem services provided. Each ecosystem asset represents a distinct spatial area with economic and human activity taking place within that area

Annex 7. Welfare economic and exchange concepts of value

This text is adapted from the SEEA Experimental Ecosystem Accounts section 5.3.2.

In neo-classical welfare economics, the value of a good or service is determined by the demand for and supply of that good or service in a perfectly functioning market. This is illustrated in Figure A1. This figure shows a demand and a supply curve for a good traded in a market in quantity 'Q' and at price 'P'. The demand and supply curves are assumed to be linear for the purpose of this illustration, but this will not normally be the case in practice.

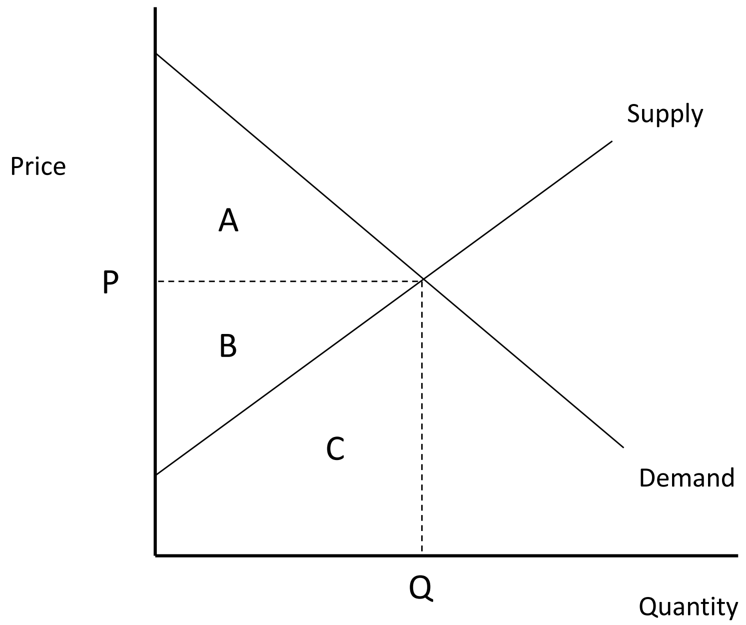

Figure A1. Producer and consumer surplus

In Figure A1, area 'A' represents the consumer surplus, which is the gain obtained by consumers because they are able to purchase a product at a market price that is less than the highest price they would be willing to pay. The producer surplus, depicted by 'B', is the amount that producers benefit by selling at a market price that is higher than the least that they would be willing to sell for, which is related to their production costs. The area 'C' represents the production costs, which differ among producers. The sum of areas A and B is labelled the 'surplus'. The surplus can be seen as the net economic gain resulting from production and consumption with a volume of Q at price P. This corresponds to the welfare economic definition of value. The market price (P) reflects consumers' marginal willingness to pay for the product at the market equilibrium quantity of services Q. In the case of ecosystem services not traded in a market, alternative approaches to establish a price or marginal willingness to pay for the ecosystem service need to be used.

For national accounting purposes, the focus of valuation is on the area of producer surplus plus costs of production, i.e. areas B and C or equivalently, is equal to P times Q. This reflects the concept of exchange value in which the total outlays by consumers and the total revenue of the producers are equal. For national accounting purposes, this approach to valuation enables a consistent recording of transactions between economic units since the values for supply and use of products are the same. In the context of comparing values of ecosystem services with values in the system of national accounts, it is necessary to value the quantity of ecosystem services at the market prices that would have occurred if the services had been freely traded and exchanged.

The differences between the welfare economic concept of value and the national accounts concept of exchange value are therefore the inclusion of consumer surplus (A) in the former and the inclusion of production costs in the latter (C). The welfare economic concept of value corresponds to a theoretically valid measure of welfare in the sense that a change in value represents a change in welfare for the producers and/or consumers of the product(s) under consideration. The concept of exchange value does not correspond to a theoretically valid measure of welfare in the sense that a change in value does not necessarily represent a change in welfare for either producers or consumers.