Forum of Experts in SEEA Experimental Ecosystem Accounting

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Provisional List of Issues for Testing and Further Research

The purpose of this document is to summarize the issues for testing and further research emanating from discussion of the SEEA-EEA. These discussions have been held with experts and countries as part of the Advancing the SEEA-EEA Project. This is intended as a companion piece to the Technical Guidance Document, which explains the fundamental concepts.

"Issues for testing" refers to approaches that reflect the core concepts developed in the SEEA-EEA, but have been further refined by testing in some countries. In some instances, the countries have developed alternative approaches. In other instances, no common guidance has evolved from the discussion. Therefore, "issues for testing" are those areas in which countries taking experimental ecosystem accounting forward are encouraged to evaluate different approaches to determine which work best in their context. Reporting on the results of these tests is integral to the further refinement of the SEEA-EEA.

"Issues for research" refers to research questions for which there is a lack of consensus or there has been little research. However, these areas are important to explore so that alternatives can be developed for countries taking experimental ecosystem accounting forward.

Experts are encouraged to contribute to both sets of issues:

- *Are there other issues for which options exist and opportunities for testing exist?*
- *How could these issues be incorporated into your research?*

Session 2: Ecosystem accounting units – discussion of approaches and methods

Fundamental to all accounting is the need for a clear framework to delineate accounting units. The challenge in ecosystem accounting is finding a match between ecological units and accounting units such that (dis)aggregation can occur systematically and the ecosystem services for each unit can be identified consistently. This session aims to review examples from ongoing activities, advance understanding of and provide recommendation on the techniques and information available to measure and classify areas of land and other spatial areas for the purpose of delineating and classifying spatial units for ecosystem accounting.

Issues for testing

Delineating spatial units using the highest-resolution land cover data is a practical starting point for most countries. However, the recommended hierarchical spatial units recommended in the SEEA-EEA (Basic Spatial Unit (BSU), Land Cover Ecosystem Functional Unit (LCEU) and Ecosystem Accounting Unit (EAU)) raises several issues that can be addressed by further testing:

- *What criteria, in addition to (or instead of) land cover, should be used to delineate the LCEU?* Countries have applied: land use, ownership, hydrology, soil classifications, infrastructure networks, topography, protected areas, management areas species habitats, and existing ecological classifications.
- There is no general advice in the SEEA-EEA on other "intermediate" spatial units, such as river, coastal and marine units. Some countries have also defined socio-ecological landscapes by combining land cover and land use into a single classification. *Given a range of possible spatial units, what data is most appropriate to be compiled at each level (see **Table 1** for a provisional example)?*
- The structure of the accounts suggests that ecosystem condition (including water, biodiversity, carbon) and services generation be reported by LCEU type for each EAU (reporting area). *Should data be maintained at the scale at which they are collected or transformed to one spatial scale (e.g., the BSU) for subsequent compilation of the accounts?*
- What is the effect of the size of the BSU (or pixel)? Using larger BSUs may introduce additional uncertainty by hiding spatial patterns within the unit. *Is one size appropriate for both national-level and local-level analysis?*
- How accurate is the interpretation of satellite data for land cover? Alternative sources and interpretations of the same area could be ground-truthed and compared to determine the level of accuracy. The degree of uncertainty in the land cover data should be measured and reported. *What is the most appropriate approach to measuring this uncertainty?*
- Spatial models to support decisions about ecosystem services embed approaches to delineating spatial units, scaling, aggregation and the treatment of uncertainty. These should be further assessed to determine if there are best practices that could be suggested in testing ecosystem accounting.

Issues for further research

Testing will develop options among available ones, but research is requires to develop and evaluate new options:

- Although these issues are mentioned above in reference to testing, their further application in researcher could support the development of coherent approaches for (a) the treatment of freshwater, coastal, marine ecosystems (benthic and pelagic) and (b) determining best practices for measuring uncertainty in land cover interpretation.
- There are opportunities to link soil science with ecosystem accounting to better understand, for example, how soil classifications may be used as criteria for delineating spatial units. *What does the classification of a soil tell us about the condition of the ecosystem and the capacity of that ecosystem to generate services?*
- *How should connective phenomena such as hydrological networks, airsheds and disjoint habitats (e.g., species that breed in one area and winter in another) could be treated in ecosystem accounting?* This links to the discussion of inter-ecosystem flows of "intermediate" services in the section below on ecosystem services classification.
- Spatial areas based on land cover alone do not constitute "optimal" units that apply frequently-available data and capture the underlying spatial patterns. *What are the appropriate data sources, pixel sizes and treatment of uncertainty in delineating these "optimal" units?*

Supporting documents

- SEEA EEA Technical Guidance 8: Spatial units, scaling and aggregation (21Jan2015)

Table 1 Proposed framework for linking data and analytical output with spatial level

Spatial scale	Data	Type of analysis
BSU	Land cover, location	Land cover change
LCEU	Land use, soil type, slope, elevation, location within catchment, species abundance, biomass	Local service production, local service-beneficiary linkages
Landscape	Barriers, habitats, ecological interactions, beneficiaries, micro-climate, local drivers of change (e.g., population, industry), visitor rates, streamflow, erosion rates	Fragmentation, heterogeneity, inter-ecosystem flows, biodiversity
Drainage area	Freshwater availability, recharge rates	Water-based phenomena such as flow of water, pollutants and nutrients.
EAU	Management regime, environmental activities (expenditures, management), beneficiaries	Aggregate of all of the above.
National	Socio-economic drivers, beneficiaries	Trends in all of the above; national beneficiaries
Global	Climate, socio-economic drivers, beneficiaries	Global trends in all of the above; global beneficiaries;

Session 3: Ecosystem service classification and links to ecosystem functions and conditions

This session will discuss issues associated with the classification of ecosystem services and their relationship with ecosystem function and condition. It is importance to have a robust classification of ecosystem services that are exhaustive but flexible for the purpose of ecosystem accounting.

There are two clear challenges – 1) what is the boundary to define the services; and 2) What is the link between functions, conditions and services? This session aims to identify a common approach to the classification of ecosystem services, and to provide recommendations on specific classification issues to advance its development and application in ecosystem accounting.

Issues for testing

Testing existing services classification frameworks (such as CICES and FEGS) can inform a body of best practices on their implementation by:

- Testing the appropriateness of the CICES approach (a checklist with beneficiaries and ecosystem types not specified), FEGS (which focuses on beneficiaries of specific ecosystem services) and other approaches to distinguish between "final" and "intermediate" ecosystem services and "final" services from "benefits".
- *What are the appropriate units of measure and data sources for each service type?* CICES suggest measures for some, but not all, services. Alternative measures should be suggested and tested.
- *What is the appropriate unit to use as a basis to report ecosystem services?* The functional approach (Technical Paper: SEEA EEA Tech Guide 1 Functional approach to ecosystem accounting) has been proposed to define the unit and also to account for services. This approach also proposes using ecological principles to define the unit, measure its condition and estimate the services.
- *A number of countries have undertaken a functional classification of their ecosystem assets.* Can these approaches be compared across countries in a meaningful to ensure consistency in accounting and reporting?
- In many countries, there is a close relationship between ecosystem services, poverty, food security, water security and employment. Conducting case studies on these relationships would help determine the dependence of local populations and businesses on ecosystem services.

Issues for further research

Further research could improve the conceptualization and coherence of future ecosystem services classifications by:

- *What is the best way of developing indices of ecosystem services that integrate diverse measures such as tonnes, risk and amenity into a composite non-monetary index?* This is linked to the boundary issue since ecosystem services may have several distinct "target" benefits and

beneficiaries (economic, health, security, good social relations). Multiple indices could be developed and tested.

- *How could we disentangle the multiple roles of some services (e.g., bees provide pollination services to crops, but also serve as food for iconic bird species) and the functions that support them?* This could be done initially by conceptually linking ecosystem conditions and functions with services and between services (e.g., crops needs pollination, water regulation and soil formation; in turn pollination needs bees and bee habitats, water regulation needs appropriate vegetation, and soil formation needs soil biota). Further research may determine which of these functions may require more frequent monitoring and inclusion into an ecosystem account.
- *How could we incorporate the concept of ecosystem "disservices" (e.g., nuisance and disease form mosquitoes from wetlands and risk of disease and injury from wildlife) and negative externalities (such as morbidity and mortality from environmental conditions and economic losses from pests and nuisance species)?*
- *Which ecosystems generate which services?* This could provide one source of links between ecosystem type, functions (including inter-ecosystem flows of "intermediate services"), condition and services. *Is there a need for a "master list" for all countries or should each ecosystem be managed to optimize its own services?*

Supporting documents

- SEEA EEA Technical Guide 1 Functional approach to ecosystem accounting (30March2015), http://unstats.un.org/unsd/envaccounting/workshops/eea_forum_2015/lod.asp

Session 4: Ecosystem service measurement and modelling – methods used to estimate ecosystem services being provided by ecosystem functions and assets

Many ecosystems and their properties (including biodiversity) are linked with current and potential services flows. Often such properties relate with resilience and adaptability in view of environmental change and can be characterised through asset condition and capacity. Many of the ecosystem services flows (water and air purification, carbon sequestration, waste assimilation etc.) are provided by ecological or bio-physical functions (evaporation, transpiration, recharge, runoff, carbon, biomass accumulation) that are difficult to observe and must be modelled. Modelling these processes has been occurring for decades but the challenge accounting brings is the need to understand data uncertainty (both input and output from models) and the appropriate scale at which the model can be applied and feasibly linked with economic transactions. This session aims to review the advances of measurement and modelling techniques, examine the link between assets' condition and capacity and the impact on the flow of ecosystem services. It will discuss the progress of methods used to estimate ecosystem services being provided by ecosystem functions and assets with an objective to advance our understanding of the criteria to assess a model's ability to be used for the measurement of ecosystem services for ecosystem accounting. The session will also evaluate a few selected models against a set of criteria including data input requirement to examine their suitability for accounting purpose.

Issues for testing

In terms of the criteria for assessing a model's ability to be used for the measurement of ecosystem services for ecosystem accounting, Bagstad *et al.* (2013) provide a useful starting set: quantification and uncertainty, time requirements, capacity for independent application, generalizability, non-monetary and cultural perspective, and affordability, insights and integration with existing environmental assessment. The latter point suggests that models should be assessed with respect to whether they provide additional information to environmental assessment approaches already used in countries. Models could be further assessed in terms of:

- **Applicability at a national level**: This is related to scalability, but further implies the need to incorporate multiple ecosystem types and multiple services. Models should also be tolerant of the scarcity of data);
- **Amenability to official statistics**: Are assumptions and estimates well-documented? Are the outputs fit for use according to statistical quality guidelines? Does the tool require specialist knowledge that is not normally available to National Statistical Offices?
- **Opportunities for using national or global-level official statistics**: Could the tool benefit from incorporating standard data, classifications and concepts?

There is a need for production functions to link measures of ecosystem condition with service flows. This is required for situations where data are incomplete, but also for estimating future flows of services. Further assessment of these models could identify:

- production functions that could be adapted to national services generation estimation, and
- the best way to focus calibration of the production functions to local conditions.

The SEEA-EEA suggests that a core set of condition measures be attributed to each LCEU characteristic (vegetation, biodiversity, soil, water and carbon). It recommends that these measures be indexed to a "reference state" and combined into an overall index of ecosystem condition for each spatial unit. This approach raises several issues in terms of what measures to use and the selection of the reference state:

- Additional indicators for testing could include:
    - **Water**:
        - **Freshwater, coastal and marine ecosystems**: The nature of the vegetation (number of classes) and invasive species;
        - **Inland Waters Bodies and Open Wetlands**: Variability of streamflow (historical and recent), Hydrological Retention Time (HRT) for wetlands
        - **Coastal Water Bodies and Sea**: Wave intensity (historical and current);
    - **Biodiversity**: Diversity indices;
    - **Soil**: Soil class, soil moisture content, topsoil texture and degree of erosion, toxic substances;
    - **Carbon**: Carbon loss from respiration and metabolic efficiency in terms of respiration as a fraction of total biomass.
- The notion of ecosystem components/characteristics could be expanded to include air as a component and to record air quality and other physical characteristics (such as temperature, wind direction and velocity). *Are there other "abiotic" components, functions and processes that need to be accounted for (such as solar, wind, wave and geo-thermal energy, solar energy for photosynthesis, oxygen for combustion, air for respiration and space)?*
- The focus on individual ecosystem components does not address overall ecosystem measures such as: heterogeneity and holistic measures of ecosystem health, naturalness and integrity (fragmentation, ecosystem diversity (structural and species complexity, patchiness), corridors, buffers and gradients). *What measures are most appropriate for testing?*
- There are many approaches to defining a "reference state". The following are suggested by Certain and Skarpaas (2010): carrying capacity, precautionary level, pristine state, knowledge of past situation, traditionally-managed habitat, maximum sustainable value, best theoretical value of indices, amplitude of fluctuations experienced in the past. One could add to this list "the beginning of the accounting period" and "arbitrary period in the past". *What is the most appropriate reference state for linking changes in condition with the generation of ecosystem services?*
- The current representation of the Condition Account allocates changes in condition to drivers of change (such as natural regeneration or reductions due to harvesting) to each condition measure. *Would allocating changes only to the condition index simplify the compilation of the Condition Account?*
- Different approaches to measuring ecosystem degradation and enhancement within the context of condition and capacity could be explored through testing. *For example, is there sufficient data and understanding of the dynamics of ecosystems to suggest standard measures of degradation, such as a decrease or increase in capacity to generate a specific basket of services?* Such

measures could be biophysical (such as the change in an overall index of capacity) or monetary (such as the change in net present value of the ecosystem asset).

- A separate Driver Account could record available socio-economic information, such as population density, changes in land use and agricultural activities (fertilizers and pesticide application) that can be used to explain changes in condition. *Would data on global, national and regional drivers (such as commodity prices, economic growth rates) also explain some changes in condition?*

Issues for further research

Could existing decision support models serve the comprehensive needs of ecosystem accounting? As Bagstad *et al.* (2013) note, specific models could address different stages in the ecosystem services assessment process: impact screening, landscape-scale modelling and mapping, site-scale modelling and mapping, non-monetary and monetary valuation. Similarly, ecosystem accounting can provide coherent data, classifications and concepts to support these models. *Together, could multiple models and ecosystem accounting develop a coordinated approach to delineating ecosystems, measuring their condition, capacity and flows of services to the economy and other human activities?*

- *Are there opportunities for the developers of the ecosystem services decision support tools and models to incorporate the principles of the SEEA-EEA and to supply reliable estimates of condition, services generation and capacity for ecosystem accounting?*

The SEEA-EEA suggests that net present value of the future flow of services from an ecosystem asset represent the value of that asset. This raises several issues that could be addressed in research:

- It is not straightforward to predict (or extrapolate) the generation of services knowing only the current ecosystem condition. This may be due, in part, to the complexity of the problem and the need for convergence among researchers to address the problem. *Using a common framework of concepts and methods, could researchers concentrate on measuring specific aspects of the "ecosystem services cascade" and more coherently inform the understanding of ecosystems and their capacity to generate services?*
- Ecosystem accounting could support linking ecosystems condition to capacity by providing:
  - A framework for codifying the functional class of species that would support research into functional diversity and resilience;
  - A framework for codifying species and ecosystem responses to changes in condition that would support research into response diversity;
  - A conceptual linkage between CICES (or other services classifications) with ecosystem type, function and "intermediate" services that would support the selection of which condition measures to include in ecosystem accounting;
  - Support further research in macro-ecological theory, modelling and scale-independent measures (such as variance and heterogeneity) that would help develop appropriate measures of ecosystem condition, capacity, degradation and enhancement.

- *Could existing ecological models be further explored to derive functional relationships to estimate future services based on scenarios of future conditions?*

Supporting documents

SEEA EEA Technical Guidance 9: Guidelines for biophysical modeling and mapping (9Dec2014)

Session 5: Structure of Ecosystem accounts – compilation of accounting outputs and tables

A sequence of ecosystem accounts is proposed for supporting the experimentation in pilot countries. The sequence reflects a series of inter-related accounts, some whose development is well advanced and some still under development. The primary ecosystem accounts that form part of any accounting exercise include accounts in physical terms for ecosystem extent and condition, the supply of ecosystem services and their use, and underlying component accounts designed to support the estimation of primary accounts and supply additional information in their own right. These component accounts cover thematic areas such as land, carbon, water and species diversity. Other accounts will also be discussed, including accounts for ecosystem capacity (to supply future services), and accounts in monetary terms such as supply and use tables for ecosystem services, ecosystem asset accounts, and augmented input-output tables and balance sheets. In developing the accounting structures there are important links to the delineation and classification of spatial units, the classification of ecosystem services and related beneficiaries, and the intended applications of the accounts in terms of research questions and scale of analysis.

The aim of discussion of ecosystem accounts at the Forum is to form a common understanding of (i) the set of ecosystem accounts and how they relate to each other; (ii) the relevant structures and appropriate levels of detail for compilation; (iii) the relevant measurement issues and practical concerns (including aggregation of indicators, valuation of ecosystem services, and the integration with standard national accounts); and, finally (iv) which accounts should be of highest priority for testing. The discussion should enable clear messages on the scope of testing to be conveyed to pilot countries and also help formulate the broader research agenda on ecosystem accounting.

Issues for testing

The following points are intended to help determine the appropriate focus for testing ecosystem accounting at national level. Some of the questions relate to forming a common understanding of the accounting structures to be tested while others relate to areas of compilation that might be tested.

- Are the account structures and titles outlined in the draft SEEA EEA Technical Guidance appropriate both conceptually and from the perspective of organising information in a useful manner for analytical and policy work?

- What spatial scales/units and classifications should be the focus of the different accounts? At what level of account structure might some degree of international comparison be undertaken?

- How should component accounts (e.g. for carbon, water, biodiversity, etc) be structured to best support the compilation of ecosystem accounts?

- Is the sequencing of the accounts appropriate (largely from physical to monetary) or can alternative approaches to the development of the accounts also be considered?

- What is the role of the ecosystem capacity account and how can it best be structured to link measures of ecosystem condition and ecosystem services?

- What techniques might be adopted for aggregating different physical measure of ecosystem condition? How should connections to reference/benchmark conditions be incorporated?

- For accounts in monetary terms it would useful to understand how feasible the derivation of net present value for ecosystem assets is and to examine how best to integrate the value of ecosystem assets into the standard national accounts balance sheet. For example, how should the market values of agricultural land be reconciled with value of agricultural land obtained via the valuation of ecosystem services?

- Are there other presentations of information other than accounts (e.g. maps, composite indicators) that should be develop and if so, what aspects of ecosystem accounting should they target?

Issues for further research

The following points describe those research issues thought to be most important in finalising a complete set of accounts for ecosystems including the integration of information on ecosystem services and ecosystem assets into the standard national accounts.

- How should degradation be defined? In SEEA EEA (section 4.2.3) ecosystem degradation is defined in general terms as relating to a fall in condition due to economic or human activity. This leaves out of scope of degradation falls in condition due to natural causes (storms, etc) and there is not necessarily a direct link between condition and changes in ecosystem services. The bigger issue raised in SEEA EEA is the treatment of ecosystem conversions where a whole ecosystem is changed – to which reference condition should the assessment of change in condition be compared? An emerging question is whether degradation should be measured in relation to a change in condition or to a change in capacity to supply ecosystem services. These

are clearly related but to what extent do they differ? Overall can a more precise definition of degradation be determined?

- The view expressed in SEEA EEA Technical Guidance is that the value of degradation should be based on the calculation of the change in the net present value of the ecosystem asset (after taking into account other changes in net present value (e.g. revaluations, catastrophic losses, etc). The SEEA EEA itself noted other approaches included restoration cost (of the ecosystem). Determining a clear conceptual outcome on the valuation of degradation would be a positive outcome.

- Progress is needed on the allocation/attribution of degradation to economic units. This has been an unresolved SEEA discussion since the first SEEA in 1993. SEEA EEA notes a few options (see SEEA EEA section 6.3.3 and Annex A6) as do Edens and Hein (2013). Can a clear path forward be determined?

- The treatment of ecosystem enhancement (through human intervention) is yet to be determined. The issue is that there is likely some connection to the treatment of gross fixed capital formation (GFCF) on land improvement as currently recorded in the SNA. Currently the SNA would record the level of expenditure on land improvement as GFCF but within an extended boundary for ecosystem services, an alternative might be that GFCF is recorded equal to the increase in the NPV of ecosystem services as a result of the activity. Research into the appropriate accounting treatment is required.

- The sequence of ecosystem accounts end with the integration of ecosystem information into the standard set of national accounts. The SEEA EEA Technical Guidance outlines two main ways of integration. The first way, which is also described in the SEEA EEA, is to create a sequence of accounts (production, income, capital, balance sheets) that take into account degradation and the value of ecosystem assets. The second way is to develop an augmented input-output table that recognises the expanded production boundary and hence adds additional rows and columns to the standard I-O table. Are these approaches appropriate and/or are there other alternative integrated accounts that might be formulated?

Supporting documents

SEEA Experimental Ecosystem Accounting: Technical Guidance (see Chapter 4: Main ecosystem accounts)