Advancing SEEA Experimental Ecosystem Accounting

A summary of the paper on spatial units, scaling and aggregation methods and approaches

0. Document information

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Version: 1.0 (Final)
Review history:

- Version 1.0 (Final) 30MAR15

Acknowledgements: The author would like to thank the project coordinators (UNSD, UNEP and the CBD), sponsor (the Norwegian Ministry of Foreign Affairs) and the reviewers, who contributed valuable insights.

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1. Spatial Units

1. **Spatial units** are the basic building blocks for the analysis of location-specific attributes. The SEEA Central Framework operates largely at the national level. The SEEA-EEA recommends a much finer spatial scale to compile information about ecosystems. For example, land cover change may be summarized at the national level. However, a land cover change matrix requires smaller spatial units to calculate what types of land cover changed and what they changed into.

2. Since the objective of the SEEA-EEA is to compile information about ecosystems, the core statistical unit is a **spatial unit** for which measures associated with terrestrial (including open wetlands and inland water bodies), freshwater and marine and coastal ecosystems are compiled.

3. The SEEA-EEA recommends a hierarchical classification of spatial units, based on surface characteristics:

   - **The Basic Spatial Unit (BSU)** is the smallest spatial area. That is, it is normally not further subdivided. It can be a remote sensing “pixel”, a larger grid cell (e.g., 1 km^2) or a land parcel (such as represented by cadastral or ownership information).
   - **The Land Cover Ecosystem Functional Unit (LCEU)** is an aggregation of contiguous BSUs with homogenous characteristics (such as land cover, elevation, drainage area and soil type). An LCEU is classified into one of the 16 classes (Figure 1) in the provisional land cover classification. Many of the tables in the SEEA-EEA are based on aggregating other characteristics (such as extent, condition, service flows) over LCEUs of similar class. While not strictly delineating an ecosystem, the LCEU can be considered an operational definition for the purposes of ecosystem accounting.
   - **The Ecosystem Accounting Unit (EAU)** is a reporting aggregate of LCEUs. This may be a natural unit, such as a drainage area, or an administrative unit, such as province, resource management area or state. The delineation of the EAU is relative to the reporting purpose, but given the hierarchical nature of the classification, LCEUs should not cross EAU boundaries.

1.1 Issues with spatial units (as defined in the SEEA-EEA)

4. In terms of delineation, the current cover classification applies best to terrestrial areas with only one level of vegetation canopy, therefore,

- the treatment of freshwater, marine and sub-soil ecosystems is not well defined,
- dependence on satellite imagery alone will obfuscate certain important surface characteristics,
- an LCEU classification based only on land cover would ignore the fact that different parts of an LCEU may be under different management regimes,
- different parts of an LCEU may exhibit different conditions, for example, levels of degradation,
- the treatment of airsheds and other connective phenomena are not defined,
- **Added:** an LCEU is not an ecosystem (it may not be an "optimal unit" for ecological analysis)
- **Added:** an LCEU does not necessarily take into account important gradients and transitions between ecosystem types (i.e., ecotones)

5. The choice of BSU size will impose different assumptions and approximations on the results and thereby affect the interpretation of the outcome.

6. Some implementations of ecosystem accounting attribute all information to the BSU level and then generate analyses for larger-scale areas (e.g., drainage areas, conservation areas, ecosystem types) as required. This may avoid one set of issues, such as delineating homogenous LCEUs and aggregating conditions or services to the LCEUs. However, for more comprehensive ecosystem accounts, this approach may complicate compilation and analysis.

1.2 Recommendations

For testing

7. Land cover information should be combined with information from other sources, such as hydrology, road networks, ownership and soil surveys can improve the creation of homogenous LCEUs.

8. Spatial information should be maintained in an appropriate level of detail. Rather than scaling all data to the BSU or LCEU level, maintaining data at their appropriate scales would ensure that biases introduced by scaling are minimized. If the purpose of the ecosystem account is to generate only national-level aggregates, then large (e.g., $1km^2$ or larger) BSUs may be appropriate. However, if the purpose of the ecosystem account is also to "drill down" to investigate local phenomena, smaller-scale (e.g., 30m) BSUs may be required.

9. Whereas BSUs and EAUs are relatively time-invariant, LCEUs are not. Defining new LCEUs for each accounting period would remove this source of error. This could be addressed by testing the implications of treating LCEUs and other intermediate spatial units as time-invariant in comparison with redefining intermediate units for each accounting period.

10. Testing should investigate:

- approaches to delineating LCEUs (beyond satellite imagery) including freshwater, coastal and marine units.
- criteria for and testing other intermediate spatial units (such as landscapes, viewscapes and river units)
- linking levels of spatial units with specific information (See **Table 1**, for example)

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;

- how spatial units are treated in various ecosystem services models.

For further research

2. Further research will be required to address:

- the treatment of freshwater, marine and sub-soil ecosystems
- the treatment of airsheds and other connective phenomena
- the creation of units that are more optimal for ecological analysis

3. Scaling

11. **Scaling** is the process of attributing information from one spatial, thematic or temporal scale to another. Information on ecosystems, including their condition, services and beneficiaries occur on many different scales. Therefore, compiling ecosystem accounts requires guidance on how to attribute this information from one scale to another. This also includes the methods of transferring information from one location to another.

12. All aspects of ecosystems, their functions, processes, conditions, services and beneficiaries occur at various spatial and time scales. Furthermore, simple or more complex classifications are used to analyse these. Ecosystem accounting needs to be aware of these scales and develop appropriate approaches to scaling from one to another.

13. It is important to choose appropriate spatial, temporal and thematic scale for the phenomenon that we are measuring and the scale of the decision to be made with it.

14. If data are not uniformly distributed, downscaling those data can introduce a bias in the result. Testing the SEEA-EEA should investigate alternative data used to downscale spatial data.

3.1 Recommendations

For testing

15. Scaling of data in ecosystem accounting requires attention to:

- The scale of the phenomenon being measured

- Sources of error and their treatment: Testing the SEEA-EEA should encourage the reporting of uncertainty in all aspects of the data collection and transformation process.
- Underlying patterns in the data
- Uniformity of distribution of underlying data
- The amenability of the data to scaling

16. Testing the SEEA-EEA could contribute to the improvement existing Benefits Transfer values databases and future valuation studies by providing standard classifications of services, ecosystem types, conditions, services and valuation methods used.

17. Benefits transfer approaches should be tested, but not necessarily with the objective of transferring monetary values. Methodologies developed for function transfer of ecosystem services benefits could also be applied to imputing biophysical measures and the levels of uncertainty in this imputation.

18. The implications of spatial, thematic and temporal scaling on the interpretation of the resulting indicators could be addressed by running parallel analyses.

19. Scaling daily or monthly data on ecosystem condition measures could help inform the choice of scale, but also the treatment of uncertainty. Non-linear approaches, such as semivariograms, spectral analysis and fractal analysis should be considered.

20. The treatment and reporting of uncertainty in the interpretation of spatial information could be addressed, in part by parallel testing of different methods of interpretation.

21. Best practices could also be developed around downscaling. For example, what data could be used to allocate specific measures to smaller spatial scales?

For further research

22. Further detail on treating sources of error should be considered as an element of the future research agenda for the SEEA-EEA.

23. Scale-independent measures (such as variance) and their treatment should be further investigated.

24. One generally-applicable tool that could be developed is a framework for recording valuation studies. A standardized approach to codifying location, ecosystem type, condition measures, socio-economic conditions, ecosystem service and valuation method used would benefit researchers conducting these studies as well as users of the data.

25. Another tool that could be developed would be to codify the individual CICES services in terms of the scale of the service and the scale of the beneficiary. This would complement codifying the CICES services in terms of ecosystem types and linking to ecosystem functions suggested in an accompanying report (Bordt 2015).

4. Aggregation

26. **Aggregation** is the process of reducing many measures to simpler ones. When these measures are the same (such as dollars in the SNA), the process is relatively straightforward. When measures, units and scales are different, other approaches such as conversion to common units and the creation of indices are required.

27. The SEEA-EEA addresses aggregation at several levels:
    - The aggregation of spatial units (para 2.51)
    - Aggregation of ecosystem condition (para 2.95, para 4.86)

- Aggregation across different ecosystem services (para 2.88, 3.65)
- Aggregating future ecosystem services to provide an estimated stock of future ecosystem service flows (para 2.31, 4.85)
- Providing aggregate information for measuring trends and comparing ecosystem assets for policy and analytical purposes (para 4.4)
- Aggregation for ecosystem accounting in monetary terms (para 5.112)

28. This section will focus on advancing our understanding on selected issues:

- Aggregating biophysical measures of ecosystem condition and capacity (including the selection of a reference state)
- Aggregating biophysical measures of services
- Aggregation by creating a composite index
- Producing final aggregates that are applicable to various decision contexts

4.1 Recommendations

For testing

29. Ecosystem services can be analyzed in "bundles" that are closely associated. with each other. This would avoid the need for aggregating ecosystem services into one composite index.

30. Some reference states for individual provisioning services could be derived from existing work on resource management, such as maximum sustainable yield (MSY) in fisheries and optimal harvest in forestry. Regulating and maintenance and cultural services could be benchmarked to optimal or past reference states.

31. A "dashboard' of key indicators that reflect the state and changes in state of important ecosystem conditions and services would better reflect the complexity of ecosystems than a single composite indicator.

32. Testing the SEEA-EEA would benefit from the development of certain tools that would support the determination of reference conditions and priorities among (and linkages between) ecosystem services:

- a "dashboard" of several key aggregates (e.g., ecosystem condition sub-indices, services bundles) that would communicate the complexity of changes in ecosystems to a variety of decision contexts.
- a compilation and codification of actual reference states for ecosystem condition and services
- a detailed survey of experts on the priority of ecosystem services. This could support the development of weights for aggregation. By including decision makers as well, it could also establish priorities for reporting on different decision contexts.
- by linking directly to the CICES, the nature of the recommended benchmark (optimal yield, past condition, sustainable level) and level of criticality could be recommended for each service.
- A review of how various ecosystem services models treat aggregation and the final aggregates they present would also provide valuable insights.

For further research

33. Rather than weighting ecosystem services *a priori*, guidance could be provided on establishing appropriate weighting schemes across subsets (bundles) of services.

34. The practical choice of reference states for ecosystem accounting requires further research through testing and literature search. The examples investigated suggest that a pristine state (or pre-development state) may be a good benchmark.

35. More attention should be given to the relative importance of services, not only to the economy, but also to long-term human and ecological well-being. Being aware of (a) the uncertainties of the underlying information and (b) the opportunities for informing a wide range of uses should support the determination of "*relevant aspects of ecosystem assets.*"