GUIDANCE ON BIOPHYSICAL MODELLING FOR ECOSYSTEM ACCOUNTING

Bram Edens
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Outline

• Purpose
• Scope, audience
• Process
• Overview of version 1.0.
  > Outline
  > Illustration of content
• Next steps
Purpose

• Why guidelines on biophysical modeling?
  > Data needed to assemble ecosystem accounts are not typically captured in data sources statistical offices rely on
  > Ecosystem accounting being spatially explicit requires mapping
    - regularly collected information used to measure ecosystem services (e.g. agricultural surveys) needs to be spatialized.
    - water quality (from monitoring stations)
  
• Niche
  > Guidance already exists e.g. how to select tooling (e.g. Invest, SWAT, ARIES, SolVES) (e.g. CI - Neugarten et al 2018), but none address specific needs of the statistical community.

• Challenges: (1) very rapidly developing field (2) SEEA EEA not stable yet (3) multi-disciplinary
Scope and audience

• Scope
  > Terrestrial ecosystems, including primarily terrestrial datasets, definitions, modelling approaches and challenges.
  > Biophysical, mostly on provisioning + regulating services
  > Core accounts (not carbon / species etc.)

• Audience
  > Ecosystem accounts compilers + managers
  > Assumes familiarity with SEEA Ecosystem Accounting, but does not assume knowledge of biophysical modelling.
Process

- Output of the Natural Capital Accounting and Valuation of Ecosystem Services project, developed under the auspices of the SEEA EEA Technical Committee.
- Editorial Board:
  > Rosimeiry Portela (Conservation International, Chair);
  > Stephanie Tomscha (Victoria University of Wellington, Editor),
  > Bethanna Jackson (Victoria University of Wellington),
  > Ken Bagstad (USGS),
  > Francois Soulard (Statistics Canada),
  > Justin Johnson (Stanford University),
  > Michael Bordt (former UNESCAP);
  > Lars Hein (Wageningen University);
  > Glenn-Marie Lange (World Bank).
  > Bram Edens (UNSD) acted as project manager and provided the secretariat to the Editorial Board.
- In addition, experts involved in the revision process of the SEEA EEA provided comments on are contributed to various drafts.
Based on SEEA implementation strategy

4 stages in continuous process

- Strategic Planning
  - Use diagnostic tools to identify key problems
  - Consult with data users and stakeholders to determine needs and improve uptake
  - Evaluate current statistical environmental reporting

- Institutionalisation
  - Regular production of accounts
  - Mainstreaming and improvement through user feedback

- Release preparation
  - Compile ecosystem accounts
  - Produce maps and graphics
  - Make data FAIR (Findable, Accessible, Interoperable, and Reproducible) whenever possible

- Building Mechanisms for Implementation
  - Build team with expertise
  - Explore methodology
  - Identify key datasets
  - Build local connections and networks

- Modeling
  - Select modeling approach
  - Gather data sources
  - Run selected models

- Validation and accuracy assessments
  - Document data limitations
  - Validate models

- Compiling and Disseminating accounts
Selected content Chapter 3

• Tiered approach -> recognizing countries in different circumstances
• To facilitate a progressive approach

Tier 1
Ecosystem services modelled from global datasets with no or little user input data

Tier 2
Ecosystem services modelled from national datasets customized for national contexts, some validation

Tier 3
Ecosystem services modelled with local data or direct surveys, better validation, and best available tools
Selected content Chapter 3

- Many models / platforms abound, but few developed with accounting objectives in mind
- Aligned with emerging ideas towards
  - ARD (analysis ready data – context of EO)
  - Accounting ready data

What makes a model/data ready for SEEA-EEA?

- Measureable
- Sensitive to change
- Scalable
- Spatially explicit
- Coherent
- Units suitable for economic valuation
## Selected content Chapter 3 - techniques

<table>
<thead>
<tr>
<th>Model technique</th>
<th>Definition</th>
<th>Data needs</th>
<th>Efforts involved in applying the model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lookup Table</td>
<td>Specific values for an ecosystem service or other variable are attributed to every pixel in a certain class, usually a land cover, land use, or ecosystem type class</td>
<td>Limited</td>
<td>Easy</td>
</tr>
<tr>
<td>Spatial interpolation</td>
<td>Creates surfaces from measured points</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Geostatistical models</td>
<td>Statistical algorithms predict the value of un-sampled pixels based on nearby pixel values in combination with other characteristics of the pixel</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Statistical models</td>
<td>Values of pixels are assigned based on a set of underlying variables. The relation between the value and the independent variables is developed with a regression analysis.</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
<tr>
<td>Dynamic systems (such as Process-based models)</td>
<td>Dynamic systems modelling uses sets of differential equations to describe responses of a dynamical system to all possible inputs and initial conditions. The equations include a set of state (level) and flow (rate) variables in order to capture the state of the ecosystem, including relevant inputs, throughputs and outputs, over time. Most process based models are examples of dynamic systems models that predict ecosystem services supply or other variables based on a mathematical representation of one or several of the processes describing the functioning of the ecosystem.</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Machine learning</td>
<td>A type of artificial intelligence. Machine learning uses training data to build algorithms to make predictions without explicit programming.</td>
<td>Limited</td>
<td>Moderate</td>
</tr>
<tr>
<td>Modelling platform</td>
<td>Primary goal of platform</td>
<td>Annual time step feasible</td>
<td>Spatially explicit</td>
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<tr>
<td>ARIES (Villa et al 2014)</td>
<td>ARIES (Artificial Intelligence for Ecosystem Services). Provides easy access to data and models through a web-based explorer and using Artificial Intelligence to simplify model selection, promoting transparent reuse of data and models in accordance with the FAIR principles</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>EnSym</td>
<td>EnSym (Environmental Systems Modelling Platform) is a decision support tool that is designed to answer questions about where organizations should invest in their natural resources. EnSym was specifically designed with SEEA EEA in mind.</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>ESTIMAP (Zulian et al 2014)</td>
<td>ESTIMAP (Ecosystem Services Mapping tool) is a tool for mapping ecosystem services in Europe</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>InVEST (Sharp et al 2018)</td>
<td>A compilation of open-source models for mapping and valuing ecosystem services. InVEST is the flagship tool of the Natural Capital Project and has been the most widely used ecosystem service modelling tool globally.</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>iTree</td>
<td>iTree is a tool developed by the USDA Forest Service with capabilities of modelling ecosystem services related to trees, particularly in urban settings (i.e., air filtration, carbon storage urban heat island mitigation, and rainfall interception and infiltration).</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>LUCI (Jackson et al 2013)</td>
<td>LUCI (Land Utilization Capability Indicator) provides a suite of high spatial resolution ecosystem services models designed to improve decision making around restoration and land management. LUCI is a hydrology-based tool and is well suited for mapping hydrologic process at high resolution.</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>SWAT (USDA ARS 2018)</td>
<td>SWAT (soil and water assessment tool) is a widely used watershed model for predicting the impact of land management on soil erosion and water quality</td>
<td>Yes</td>
<td>Yes, for Hydrological Response Units (i.e. semi distributed)</td>
</tr>
</tbody>
</table>
• IUCN GET as global reference classification, recognizing that many countries may have their own national classification

• Description of various global land cover products
### Chapter 5 - Condition

<table>
<thead>
<tr>
<th>ECT groups</th>
<th>ECT class</th>
<th>Indicators category</th>
<th>Indicator examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abiotic ecosystem</td>
<td>1. Physical state characteristics (including soil structure, water availability)</td>
<td>Water availability</td>
<td>Hydrological flow</td>
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<tr>
<td></td>
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<td>Reservoir stock</td>
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<td>Groundwater table</td>
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<td>Soil</td>
<td>Impervious surface</td>
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<td>Soil Organic Carbon</td>
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<td></td>
<td>2. Chemical state characteristics (including soil nutrient levels, water quality, air pollutant concentrations)</td>
<td>Air quality</td>
<td>Pollutant concentrations</td>
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<tr>
<td></td>
<td></td>
<td>Water quality</td>
<td>Pollutant concentrations</td>
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<td></td>
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<td>Dissolved oxygen</td>
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<td>Chlorophyll-a</td>
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<td>Turbidity</td>
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<td></td>
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<td>Soil quality</td>
<td>Nitrogen content</td>
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<td></td>
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<td></td>
<td>Heavy metal content</td>
</tr>
<tr>
<td>Biotic ecosystem</td>
<td>3. Compositional state characteristics (including species-based indicators)</td>
<td>Species</td>
<td>Biodiversity</td>
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<td>Corals</td>
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<td>Macroinvertebrates</td>
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<td>Fish</td>
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<td>Birds</td>
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<td>Red-list indices/conservation status</td>
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<td></td>
<td>4. Structural state characteristics (including vegetation, biomass, food chains)</td>
<td>Vegetation/Biomass</td>
<td>Vegetation density</td>
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<tr>
<td></td>
<td></td>
<td>Processes</td>
<td>NPP</td>
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<td></td>
<td></td>
<td>Disturbance</td>
<td>Fire risk</td>
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<td>Invasive species</td>
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<td></td>
<td>5. Functional state characteristics (including ecosystem processes, disturbance regimes)</td>
<td>Composition</td>
<td>Diversity</td>
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<td>Connectivity/fragme</td>
<td>Barrier density</td>
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<td></td>
<td></td>
<td>ntation</td>
<td>Patch size</td>
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<td></td>
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<td></td>
<td>Shape</td>
</tr>
<tr>
<td>Landscape and</td>
<td>6. Landscape and seascape characteristics (including landscape diversity, connectivity, fragmentation, embedded semi-natural elements in farmland)</td>
<td>Composition</td>
<td>Diversity</td>
</tr>
<tr>
<td>seascape characteristics</td>
<td></td>
<td>Connectivity/fragme</td>
<td>Barrier density</td>
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<td>ntation</td>
<td>Patch size</td>
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<td>Shape</td>
</tr>
</tbody>
</table>
Ecosystem services
• Crops, timber, air filtration, erosion control
• To be added: Carbon, water purification, water yield, recreation related services; NTFR

Definition; modeling approaches; data sources and tiers; challenges

CROP PROVISIONING

Tier 1
Coarse estimates using global data agricultural statistics (FAO)

Input data
• Land cover
• Climate data
• Fertilization rates
• Irrigation

Modelling platforms
• InVEST
• ARIES

Modelling approach
• Look up tables linking global yields to crop extent maps
• Statistical approaches estimated using climate data and global yields

Tier 2
Spatialized official agricultural statistics or global models with national spatial data

Input data
• Tier 1 +
• National crop statistics
• Soil data
• Water availability

Modelling platform
• ARIES
• LUCI (with further modeling for yield)

Modelling approach
• Computing average yield factors to spatialize
• Geospatial interpolation
• Statistical approaches

Tier 3
Sophisticated country specific models based on best available spatially explicit data sources

Input data
• Tier 1 and 2 +
• National and farm-level crop statistics
• Digital Elevation Models

Modelling platform
• LUCI (with further modeling for yield)
• Custom models

Modelling approach
• Process-based models
• Dynamic systems models
• “emergy” approaches to isolate ecosystem contribution
Next steps

• Guidelines:
  > Versions 1.0 is ready, will be circulated to a wider group of experts (including participants of this Forum)
  > In October a revised version 2.0 made public for use and testing.
  > In 2021 after SEEA EEA is final, further feedback, global consultation and develop a final 3.0 version.

• (Ideas) Online live version of Annex (data portals - main global data sources)

• Ongoing discussions with data portals, modelling community, EO community (GEOBON, EO4EA) -> develop a strategy (e.g. towards interoperability and efficient “ecosystem”)

• NB: all feedback is very welcome!
  > Contact: bram.edens@un.org; seea@un.org