Advancing the SEEA
Experimental Ecosystem Accounting

Ecosystem Service Measurement and Modelling

Advancing the SEEA-EEA Project
Overview: Measurement and Modelling ES

- Data needs for measuring ecosystem condition
- Selection reference state
- Biophysical modelling

Issues for testing:
1. Selection of models
2. Generic versus detailed
3. Reference state and indicators
4. Link ecosystem condition to capacity
5. Driver account
6. Scenario analysis

Issues for further research:
Models, future services, linking ecosystem condition to capacity

10 minute presentations

Working session: Break out groups
Measuring Ecosystem Condition

Lack of detailed data:

- Use multiple sources, combining the best, reduce errors
- Less detailed data can also be valuable
- Not all data need to be measured (or measured frequently)
- Can estimate condition or services from other condition data using **Biophysical Modelling**

Examples data and linkage to service:

- Land cover class → carbon storage
- Sampled data on forest production → estimate for other areas
- Forest cover, distance from roads, etc. → orangutan habitat
- Land use, infrastructure and fragmentation, etc. → biodiversity
- Primary production (from remote sensing), soil respiration → carbon sequestration
Measuring Ecosystem Condition

• Selection of reference state
  • Aggregates could be “arbitrary”
    • For example, average of water quality measures

• Or, indexed to a “reference state”
  • For example, compare with “quality standard” for use (drinking, recreation, livestock, wildlife, irrigation…)
  • Can compare with known past or “ideal” reference condition:
    • Pristine or `pre-development state,
    • Sustainable state (e.g. max sustainable value)
    • Earliest available information

• Choice of reference state can affect interpretation
  • e.g., Are we experiencing short-term fluctuations or a long-term trend?
Time frame: short

- Viable pop
- Tons Cod

Stock

- 2000
- 2005
- 2010

Time
Time frame: longer

System of Environmental-Economic Accounting

United Nations Statistics Division

Tons Cod

stock

Viable pop

past 2000 2005 2010 future

time
Recent baseline: Fair comparison?

Netherlands
Brazil

biodiversity

Baseline: 2000
Historic baseline: Fair comparison?

- Brazil
- Netherlands

baseline: natural state

1900 1950 2000 2050
Biophysical modelling

System of Environmental-Economic Accounting

SEEA-EEA accounts and linkages

Physical Accounts (by spatial unit)
- Ecosystem Extent Account
- Ecosystem Condition Account
- Ecosystem Services Generation Account
- Ecosystem Services Use Account
- Ecosystem Capacity Account

Monetary Accounts (by spatial unit)
- Ecosystem Services Supply Account
- Ecosystem Services Use Account
- Augmented I-O Table
- Integrated Sector Accounts and Balance Sheets

Ecosystem component accounts: Land, Carbon, Water, Biodiversity
Supporting information: Socio-economic conditions and activities, ecological production functions
Tools: classifications, spatial units, scaling, aggregation, biophysical modelling

Supporting information: SNA accounts, I-O tables
Tools: Valuation techniques
Biophysical modelling: Which type to choose

- **Types**
  - Four main approaches:
    - 1. Look-up tables
    - 2. Statistical approaches
    - 3. Geostatistical interpolation
    - 4. Process-based modelling

- **In order to**
  - Estimate Ecosystem Services across spatial units and time
  - Estimate Ecosystem Capacity from Ecosystem Condition
  - Combine data from various sources and scales (e.g., point field data and satellite data)
  - Estimate unknown data values
  - GIS-based spatial modelling approaches have methods built-in
Biophysical modelling

- **Approaches:**
  1. Look-up tables
  2. Statistical approaches
  3. Geostatistical interpolation
  4. Process-based modeling

Attribute values for an ecosystem service (or other measure) to every Spatial Unit in the same class (e.g., a land cover class).

- **Example:** Benefits Transfer
  - one ha of forest = $5000
  - attribute to each ha of forest
  - error rate: medium

Example 2:
Carbon storage Kalimantan

- High: 7882.64 ton/ha
- Low: 32.34 ton/ha
Biophysical modelling

**Approaches:**

1. Look-up tables
2. **Statistical approaches**
3. Geostatistical interpolation
4. Process-based modeling

Estimate ecosystem services, asset or condition based on known explanatory variables such as soils, land cover, climate, distance from a road, etc., using a statistical relation.

- Example: **Function Transfer**
  - \( Value = f(\text{land cover}, \text{population}, \text{roads}, \text{climate}) \)
  - Error rate = medium

Example 2: Orangutan habitat
Biophysical modelling

Approaches:

1. Look-up tables
2. Statistical approaches
3. Geostatistical interpolation
4. Process-based modeling

Use algorithms to predict the measure of unknown locations on the basis of measures of nearby known measures:

- Example: Kriging
- Error rate = ?

Example 2:
Timber production
Kalimantan

- High : 1.67 m³/ha/year
- Low : 0.42 m³/ha/year

Unknown
Known
Biophysical modelling

- **Approaches:**
  1. Look-up tables
  2. Statistical approaches
  3. Geostatistical interpolation
  4. **Process-based modeling**

  Predict ecosystem services based on a set of future condition or management scenarios:
  - Example: Scenario for future services based on expected changes in land cover, demand and management
  - Error rate = large

Example 2:
Carbon sequestration

- High : 8.52 ton/ha/year
- Low : -23.22 ton/ha/year
Issues for testing: 1. Selection of models

Which models to choose for ecosystem accounting?

- Is there an ideal set of models that can be used by all Statistical Offices?
  - With an optimal resolution, scale, data needs ….

→ There are many variables that might be different in each country:

- Purpose, policy relevancy
- Implementation scale: Global versus national versus local
- Data availability
- Desired level of detail
- Available capacity and budget
- etc.
Issues for testing: 1. Selection of models

First define requirements for your country and organization:

- Who will be using the results and what for?
  - Policy makers (for local, national, international issues), sectors, organizations, type of use, end users, desired accuracy, integration with existing assessments

- What output is required?
  - Type ES, scale / level of detail, quantitative or qualitative, time requirement, frequency, monetary or non-monetary valuation, accuracy, uncertainty

- What input data do you have?
  - Indicators, sources, scale, data quality, data frequency

- Who will implement, use and develop the models?
  - Type of organizations, institutional framework, independency, required skill level, allocated capacity

- What is the budget?
  - For data collection, purchase & implementation & development of models
Issues for testing: 1. Selection of models

Selection criteria: Characteristics of model

- Model theme
  - What type of ES are supported, what drivers and indicators are used
  - Quantitative or qualitative, includes valuation or not, policy context

- Model dimensions:
  - Model resolution, temporal coverage, scalability
  - What input is required, can it use standard statistical data and make use of SEEA classification system?
  - What are the minimum data requirements and how does it handle data gaps?
  - Can it calculate projections over time?

- Model use:
  - Complexity, required skills, ownership, international acceptance, ownership, preparation (data) and run time, stand alone or dependent on input of other models, integration with environmental themes

- Model development
  - Developed by who + purpose, open source or not, script language, can it be adjusted to local conditions, how to calibrate data and carry out uncertainty analysis
# Issues for testing: Model matrix

<table>
<thead>
<tr>
<th>Model matrix (Plansup 2014)</th>
<th>Model theme and policy</th>
<th>Model dimension</th>
<th>Model use</th>
<th>Model development</th>
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<tr>
<th>Model</th>
<th>ARIES</th>
<th>EcoAIM</th>
<th>EcoSer</th>
<th>Envision</th>
<th>EPM</th>
<th>ESValue</th>
<th>InFOREST</th>
<th>InVest</th>
<th>LUCI</th>
<th>MIMES</th>
<th>SolVES</th>
<th>Ensym</th>
<th>GLOBIO3</th>
<th>CLUE</th>
<th>Tessa</th>
<th>CEV</th>
<th>ESR (aspatial)</th>
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<th>BBOB</th>
<th>IBAT</th>
<th>IBAP</th>
<th>EBS</th>
<th>Ecometrix</th>
<th>LUCI</th>
<th>HCV</th>
<th>NAIS</th>
<th>Ecosystem Valuation Toolkit</th>
<th>Benefit Transfer &amp; Use</th>
<th>Estimation Model Toolkit</th>
<th>EcoAIM</th>
<th>NVI</th>
<th>GLUCOSE</th>
<th>INVEST models:</th>
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</table>
Issues for testing: 2. Generic versus detailed

Use of generic versus specific models: Both useful but different purposes:

**Generic models:**
- Global / (Sub-)National scale
- Strategic decisions, national/regional government, int. organizations
- Advantages: Relative simple models, low data requirement, quick run time, comparison between countries
- Disadvantages: Scale, resolution, accuracy, disaggregation limited

**Specific/detailed models:**
- Sub-national / local scale
- Local decisions, regional/local government, local NGO’s, science
- Advantages: Level of detail, accuracy
- Disadvantages: Often more complex, high data demand, skill requirements, longer run time, data often need to be aggregated if to be used for comparison between countries
Issues for testing: 3. Reference state & indicators

Defining the most appropriate reference state in order to link changes in condition with the generation of ES:

Suggestions Certain and Skarpaas (2010):
- Carrying capacity
- Precautionary level
- Pristine state
- Knowledge of past situation
- Traditionally-managed habitat,
- Maximum sustainable level
- Best theoretical value of indices,
- Amplitude of fluctuations experienced in the past

Or
- Beginning of accounting period
- Arbitrary period in the past
Issues for testing: 3. Reference state & indicators

Determining reference state and indicator testing for:

- **Water**
  - Freshwater, coastal and marine ecosystems
    - Number of vegetation classes, invasive species
  - Inland waters and open wetlands
    - Variability of streamflows past & current, hydrological retention for wetlands
  - Coastal water bodies and Sea
    - Wave intensity (past + current)

- **Biodiversity**
  - Diversity Indices

- **Soil**
  - Soil class, moisture content, topsoil texture, erosion degree, toxicity

- **Carbon**
  - Respiration loss, metabolic efficiency (respiration as fraction of total biomass)

- **Air**
  - Air quality, temperature, wind direction, solar energy, etc.
Issues for testing: 4. Link condition and capacity

Linkage between asset condition and capacity

- As some services increase (e.g., crops, timber) the quality of other services (biodiversity, heterogeneity) may decrease
  - Intensive cropping creates ecosystems that are less resilient to change.

- Some services (e.g., iconic species habitat) may be very sensitive to disturbance.

- Research on resilience of all ecosystem functions trying to understand how to better link conditions with all services.
Issues for testing: 4. Link condition and capacity

Example for provisioning services:

*(Actual) Capacity:*

The ability of the ecosystem to generate an ecosystem service under current ecosystem conditions and uses at the maximum level that does not lead to a decline in condition of the ecosystem.

*Potential Capacity:*

Capacity to *sustainably* generate an ecosystem service under the current ecosystem conditions and uses, but with ecosystem use that would prioritize the **sustainable supply of this specific ecosystem service** (and that accepts a potential decline in the capacity to generate other ecosystem services).

Issues for testing: 5. Driver account

Would a separate driver account, that records available socio-economic information, provide information that can be used to explain changes in condition?

Socio economic data, e.g. on:
- Changes in population density,
- Land use, incl. agricultural and forest use intensity and land change

Global, national and regional drivers, such as:
- Commodity prices,
- Economic growth rates
- Export and import of crops and timber
- Urban growth
- Policies on land use change and nature conservation
Issues for testing: 6. Scenario Analysis

Could scenario analysis provide information to derive information on future services?

Example: **Clue land use model**
Using land use scenarios to quantify future land use
Land use → relation with Ecosystem Condition → Ecosystem Function

e.g. In GLOBIO biodiversity model:
Relation between land use and biodiversity
+ infrastructure + fragmentation + nitrogen deposition + climate change

Future land use: Relation with future Biodiversity


### System of Environmental-Economic Accounting

<table>
<thead>
<tr>
<th>Development</th>
<th>Total projected land demand (ha)</th>
<th>Protected Area</th>
<th>%</th>
<th>HP catchment</th>
<th>%</th>
<th>Poor commune</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario 1</td>
<td>92,989</td>
<td>7,376</td>
<td>6%</td>
<td>23,022</td>
<td>25%</td>
<td>46,283</td>
<td>50%</td>
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<tr>
<td>Scenario 2</td>
<td>188,927</td>
<td>20,430</td>
<td>11%</td>
<td>54,974</td>
<td>29%</td>
<td>118,657</td>
<td>63%</td>
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</tbody>
</table>

### LAND DEMAND ALLOCATION MODELLING

**QUANG NAM, VIET NAM: LAND USE 2007 (BASELINE)**

#### Scenario 1

#### Scenario 2

### LAND DEMAND ALLOCATION MODELLING

**QUANG NAM, VIET NAM: PROJECTED FUTURE LAND USE 2020 (SCENARIO 1)**

<table>
<thead>
<tr>
<th>Protected Area</th>
<th>Area (ha)</th>
<th>Scenario 1</th>
<th>%</th>
<th>Scenario 2</th>
<th>%</th>
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<tbody>
<tr>
<td>Ngoc Linh</td>
<td>19,173</td>
<td>611</td>
<td>3%</td>
<td>1,108</td>
<td>6%</td>
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<td>Phu Ninh</td>
<td>31,000</td>
<td>3,884</td>
<td>13%</td>
<td>7,601</td>
<td>25%</td>
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<td>Que Son</td>
<td>18,605</td>
<td>309</td>
<td>2%</td>
<td>5,390</td>
<td>29%</td>
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<td>Sao La 1</td>
<td>8,024</td>
<td>7</td>
<td>0%</td>
<td>784</td>
<td>10%</td>
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<td>Sao La 2</td>
<td>9,993</td>
<td>55</td>
<td>1%</td>
<td>894</td>
<td>9%</td>
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<td>Song Thanh</td>
<td>85,594</td>
<td>2,510</td>
<td>3%</td>
<td>4,653</td>
<td>5%</td>
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<td><strong>Total</strong></td>
<td><strong>172,398</strong></td>
<td><strong>7,376</strong></td>
<td><strong>4%</strong></td>
<td><strong>20,430</strong></td>
<td><strong>12%</strong></td>
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</tbody>
</table>

**LU 2020 (SC 1)**
- Primary forest
- Lightused forest
- Secondary forest
- Agro forestry
- Degraded & Plantation
- Extensive agriculture
- Intensive agriculture
- Urban
- Other
- Rubber

**LU 2020 (SC 2)**
- Primary forest
- Lightused forest
- Secondary forest
- Agro forestry
- Degraded & Plantation
- Extensive agriculture
- Intensive agriculture
- Urban
- Other
- Rubber

Source: ADB Environment Operations Center, with support information from MARD-FPI and DoDIE Quang Nam

Disclaimer: The contents of this map, particularly thematic data and boundaries, are not necessarily authoritative.
Protected areas

Scenario 1

Scenario 2

GLOBI03 model
Recommendations for Research: Models

- Can multiple models provide enough info for ecosystem accounting?

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**Potential steps in ecosystem services assessment process**
Recommendations for Research: Models and future services

- 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?

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

- 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?
Recommendations for Research: Linking Ecosystem condition to capacity

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 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**.
Suggestions for breakout groups

1. **Selection of models:**
   - **a:** What are the most important criteria (-groups) and
   - **b:** the minimum requirements, per Ecosystem Component Account (ECA: land, water, biodiversity, carbon)?
     - Criteria; data, scale, users, gaps, link with economic data, etc.

2. **Generic versus detailed** (data and models): Give examples for both types
   - Local versus global, policy relevance, type of users and use, are details important, multiple scales

3. **Reference state and indicators:**
   - Discuss reference state(s) for common indicators per ECA

4. **Link between asset condition and capacity:**
   - Give examples per ECA
   - Capacity and Potential Capacity

5. **Driver account:**
   - Discuss additional value and give examples
     - Would a separate driver account, that records available socio-economic information, provide information that can be used to explain changes in condition?

6. **Scenario analysis:**
   - How useful are scenarios for the SEEA?
Acknowledgements

This project is a collaboration of The United Nations Statistics Division, United Nations Environment Programme and the Secretariat of the Convention on Biological Diversity and is supported by the Government of Norway.