Key Concepts

(Level 0)

October 2017
Overview

- SEEA-EEA Training (Level 0)
  - Overview of training modules
  - Basic concepts:
    - Ecosystems as "Assets"
    - Ecosystem Services Cascade
    - Accounting Principles
    - Ecosystem Accounting is Spatial
  - Accounts
  - Tools
SEEA-EEA Training

• Concepts, Accounts and Tools
• Flexible and modular (don’t need all Accounts and Tools)
• Three levels:
  • Level 0 (All participants)
  • Level 1 (Compiling)
  • Level 2 (Providing data, country examples)
• Links to related training materials:
  • Secretariat for the Convention on Biological Diversity (SCBD)
    • Quick Start Package (QSP): includes GIS exercises
  • World Bank WAVES
SEEA EEA Training Level 0

• **Learning objectives**
  • Understand the basic concepts in ecosystem accounting
  • Understand the structure, data requirements and uses of the SEEA-EEA accounts
  • Understand the basic tools used to compile the SEEA-EEA accounts

• For **technical and scientific experts**, this is:
  • Preparation for Levels 1 & 2

• For **policy experts and supporters** you will:
  • Understand how to use the accounts and who to engage in the discussion
SEEA EEA Training Level 0

- **Basic concepts and definitions**
  - Ecosystems as “Assets”
  - The Ecosystem Services “Cascade”
    - Ecosystem structure and processes, function, services, benefits and values
  - Accounting (not just “counting”) Principles
    - Assets, stocks and flows
    - Balancing the books
  - Ecosystem Accounting is Spatial
    - Geographic information systems (GIS)
Ecosystem assets: a definition

• **Ecosystem assets** are spatial areas containing a combination of biotic and abiotic components and other characteristics that function together (SEEA-EEA Sections 2.31, 4.1)

• A **forest** is an area that:
  > Can be located on a map (spatial)
  > Contains trees, shrubs, grasses, soil biota, birds, mammals, insects... functioning together with
  > The soil, water, geology (rocks), sunlight, wind...
**The Ecosystem Services Cascade**

**Ecosystem services** are the contribution of ecosystems to benefits for people...

The use of these services for generating benefits, in turn, puts **pressure** on biophysical structures and processes (e.g., by degradation or conversion).

Source: Nottingham School of Geography
Accounting principles...

- Apply to environmental data, too...
  - Double entry accounting:
    - Beginning & end of time period $\rightarrow$ reconcile changes
    - Compare two sources $\rightarrow$ reconcile and find errors
  - Time of recording:
    - Referring to same time period (accounting period)
  - Unit of measurement:
    - Same units (physical or monetary)
    - Reconciliation and aggregation
  - Consistent valuation rules:
    - Market price: Basic, producer, purchaser
  - Consistent concepts and classifications
  - Stock $\rightarrow$ Flow (Asset $\rightarrow$ Service)
Balancing the books of environmental assets

Time 1

Assets

Services

Economy and well-being

Regeneration

Waste & degradation

SEEAA
Balancing the books of environmental assets

**Assets**

Regeneration

**Services**

Economy and well-being

**Waste & degradation**
Ecosystem accounting is spatial

- Ecosystems are different and function differently depending on where they are.
- Their capacity to supply services depends on their location.
- The benefits of many services depend on whether or not the ecosystems are accessible.
- Therefore...Ecosystem accounting needs to integrate spatial and non-spatial data.
- For example, wetlands in northern Canada may have the capacity to purify water, but there is no population there to benefit from it.
Ecosystem accounting is spatial

- Geographic information systems (GIS)
  - Manage spatial information as layers
  - Have tools to integrate spatial information:
    - Overlay different data where space is the common denominator
    - Aggregate point information (e.g., water sampling station) to larger areas (polygons)
    - Attribute information from larger areas to smaller ones (downsampling)
    - Geospatial statistics (interpolation, modelling)
  - Generate tables based on common properties (e.g., land cover and land cover change)
Pop quiz!

• What is an important ecosystem type in your country and what services does it provide?

• What are examples of spatial data that you may wish to integrate into ecosystem accounting?

• Why is GIS a useful tool for ecosystem accounting?
SEEA-EEA accounts, tools and linkages

1. Ecosystem extent account
2. Ecosystem condition account
3. Ecosystem services supply and use account - physical
4. Ecosystem services supply and use account - monetary
5. Ecosystem monetary asset account

Tools:
- Classifications,
- Spatial units, scaling & aggregation,
- Biophysical modelling
- Valuation techniques

Ecosystem capacity

Thematic accounts
- Land
- Water
- Carbon
- Biodiversity

Integrated accounts
- Combined presentations
- Extended supply and use accounts
- Sequence of accounts
- Balance sheets
SEEA-EEA Accounts and Tools

Today’s session presents 2-4 slides on each topic:

Ecosystem Accounts
• Ecosystem Extent Account
• Ecosystem Condition Account
• Ecosystem Services Supply and Use Account – physical terms
• Ecosystem Services Supply and Use Account – monetary terms
• Ecosystem monetary asset account – monetary terms

Thematic Accounts
• Land account
• Water Account
• Carbon Account
• Biodiversity Account

Integrated accounts
• Combined presentations
• Extended supply and use accounts
• Integrated Sector Accounts
• Balance Sheets

Tools
• Classifications
• Spatial units, scaling and aggregation
• Biophysical modelling
• Valuation
Level 0: Account 1: Extent
Account 1: Extent

**SEEA-EEA accounts, tools and linkages**

1. Ecosystem extent account
2. Ecosystem condition account
3. Ecosystem services supply and use account - physical
4. Ecosystem services supply and use account - monetary
5. Ecosystem monetary asset account

**Tools:**
- Classifications
- Spatial units, scaling & aggregation
- Biophysical modelling

**Thematic accounts:**
- Land
- Water
- Carbon
- Biodiversity

**Integrated accounts:**
- Combined presentations
- Extended supply and use accounts
- Sequence of accounts
- Balance sheets

[SEEA logo]
Level 0: Account 1: Extent

• What?
  • *Ecosystem assets* are spatial areas containing a combination of biotic and abiotic components and other characteristics that function together (SEEA-EEA Sections 2.31, 4.1)
  • National coverage of terrestrial, freshwater, coastal and marine areas
  • Mutually exclusive and exhaustive coverage

• Why?
  • Land management, conservation policies
  • Spatial foundation for other accounts
    → basis for allocating macro data to spatial units
  • Builds on SEEA-CF (land, forest, water)
  • Indicators:
    • Land cover change → where changes occurring
    • Land cover/use intensity → who owns it
Level 0: Account 1: Extent

What does an Extent Account look like?

Maps

Ownership

Use

Cover

Tables

<table>
<thead>
<tr>
<th>Cover</th>
<th>Urban and associated</th>
<th>Rainfed hectares</th>
<th>Forest tree cover</th>
<th>Inland water bodies</th>
<th>Open</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>cropped</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Infrastructure</td>
<td>Residential</td>
<td>Maintenance</td>
<td>Forestry</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ownership</td>
<td>Government</td>
<td>Private</td>
<td>Government</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Use</td>
<td>Public</td>
<td>Private</td>
<td>Private</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Units</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Opening stock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Additions to stock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Managed expansion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Natural expansion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Reductions to stock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adjusted expansion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Natural regression</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Closing stock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Spatial units
Classifications
Level 0: Account 1: Extent

What does an Extent Account look like?

Maps

Ecosystem type

Spatial units Classifications

<table>
<thead>
<tr>
<th>Proxy ecosystem type (based on land cover)</th>
<th>Artificial surfaces</th>
<th>Herbaceous crops</th>
<th>Woody crops</th>
<th>Multiple or layered crops</th>
<th>Grassland</th>
<th>Tree-covered areas</th>
<th>Mangroves</th>
<th>Shrub-covered areas</th>
<th>Sparse natural vegetated areas</th>
<th>Territorial barren land</th>
<th>Permanent snow and glaciers</th>
<th>Inland water bodies</th>
<th>Coastal water and inter-tidal areas</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
</tr>
</tbody>
</table>

Opening extent

<table>
<thead>
<tr>
<th>Additions to extent</th>
<th>Managed expansion</th>
<th>Natural expansion</th>
<th>Upward reappraisals</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Reductions in extent</th>
<th>Managed regression</th>
<th>Natural regression</th>
<th>Downward reappraisals</th>
</tr>
</thead>
</table>

Net change in extent

Closing extent
Level 0: Account 1: Extent

• What does an Extent Account look like?
  An integrated spatial (GIS) database that overlays:
  • Land cover: forest, wetland, lake…
  • Use and intensity of use: agriculture, forestry, protected…
  • Ownership: business, private, government
• Classified into **Spatial Units**
• At high resolution (30m to 100m, maximum 500m) with national coverage
• For two or more periods (change over time)
• Based on comparable **Classifications**, quality, methods and **Spatial Units**
• Units: hectares
• Records: opening stock, closing stock, additions, reductions
Level 0: Account 1: Extent

- What do you need to compile an Extent Account?
  - GIS platform: software, protocols, spatial units
  - Classifications: land cover, land use, ownership
  - National level data:
    - Existing land account would be useful
    - Satellite: land cover, aerial photography
    - Census: agriculture, population, settlements
    - Forest inventories
    - Hydrological, topographic (rivers, drainage areas, elevation, coastlines)
    - Cadastral (ownership, tax)
  - Expertise:
    - Land managers, ecologists, geographers (GIS, satellite imagery, integration)
Level 0: Account 2: Condition
Account 2: Condition

SEEA-EEA accounts, tools and linkages

1. Ecosystem extent account
2. Ecosystem condition account
3. Ecosystem services supply and use account - physical
4. Ecosystem services supply and use account - monetary
5. Ecosystem monetary asset account

Tools: Classifications, Spatial units, scaling & aggregation, Biophysical modelling
Tools: Valuation techniques

Thematic accounts
- Land
- Water
- Carbon
- Biodiversity

Integrated accounts
- Combined presentations
- Extended supply and use accounts
- Sequence of accounts
- Balance sheets
Level 0: Account 2: Condition

• What?
  > **Ecosystem condition** reflects the overall quality of an ecosystem asset, in terms of its characteristics. (SEEA EEA paragraph 2.34)

• Why?
  > Policies to limit degradation of natural heritage, rehabilitation of degraded ecosystems
  > Links to capacity to produce services (**Services Supply**)
  > Indicators:
    - Indices of condition ➔ change over time ➔ where changes
    - Good/bad condition (exceeding “safe” levels) ➔ where
Level 0: Account 2: Condition

- What does a Condition Account look like

Maps

- Carbon
- Water
- Soil
- Biodiversity
- Vegetation

Tables

<table>
<thead>
<tr>
<th>Ecosystem type</th>
<th>Ecosystem extent (ha)</th>
<th>Vegetation</th>
<th>Biodiversity</th>
<th>Soil</th>
<th>Water</th>
<th>Carbon</th>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban and associated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rangeland</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Freshwater wetland</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forest tree cover</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inland water bodies</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open water bodies</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Scaling & aggregation
**Level 0: Account 2: Condition**

- **What does a Condition Account look like?**
  - Spatially-detailed condition measures (quality or biophysical) for each characteristic:
    - Vegetation
    - Biodiversity (species abundance, diversity indices)
    - Soil
    - Water
    - Carbon
    - Air
    - Overall measures (e.g., heterogeneity)

- **Selected** to reflect an area’s capacity to generate services

- Summarized in terms of an **index**

- Accounts for changes over time (accounting period)

- Attributes changes to **drivers** (natural and human)
Level 0: Account 2: Condition

- What do you need to compile a Condition Account?
  - Ecosystem Extent Account
  - Common spatial database (Spatial units)
  - Data:
    - Condition measures from satellite imagery and field studies over two periods of time
    - Environmental monitoring data (water, air, soil, species)
  - Expertise:
    - Ecologists (vegetation, soil, water)
    - Statisticians (methodologists to create indices, Scaling, Aggregation)
    - Environmental policy analysts (focus on relevant indices)
    - Geographers (GIS, remote sensing, integration)
Level 0: Account 3: Services supply and use - physical
Account 3: Services supply and use - physical
Level 0: Account 3: Services Supply

• What?
  • Physical flows of “final” ecosystem services from ecosystems to beneficiaries
  • Directly used by (or affect) people

• Why?
  • Inform policies of contribution of ecosystems to human well-being
  • Assess trade-offs between development and conservation
  • Link to standard economic production measures in SNA
  • Link to other SEEA-EEA accounts (Condition, Services Use, Monetary Ecosystem Services; Ecosystem Monetary Asset valuation)

• Indicators:
  • Flows of individual services (physical and monetary) ➔ change
  • Indices of aggregated services by ecosystem type ➔ change
Level 0: Account 3: Services Supply

<table>
<thead>
<tr>
<th>Service Group</th>
<th>Final Ecosystem Service</th>
<th>Mountains, Moorlands &amp; Heaths</th>
<th>Semi-natural Grasslands</th>
<th>Enclosed Farmland</th>
<th>Woodlands</th>
<th>Freshwaters – Openwaters, Wetlands &amp; Floodplains</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provisioning</td>
<td>Crops</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Livestock/Aquaculture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Fish</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Trees, standing vegetation, peat</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Water supply</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cultural</td>
<td>Wild species diversity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Environmental settings: Local places</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Environmental settings: Landscapes/seascapes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: UK National Ecosystem Assessment (2011)
Level 0: Account 1: Services supply

What does an Ecosystem Service Supply Account look like?

Maps

Ecosystem extent

Provisioning

Regulating

Cultural

Tables

<table>
<thead>
<tr>
<th>Type of service</th>
<th>Ecosystem type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban and associated</td>
<td>Forest tree cover</td>
</tr>
<tr>
<td>Provisioning</td>
<td>e.g., tonnes of timber</td>
</tr>
<tr>
<td>Regulating</td>
<td>e.g., tonnes of CO₂ stored / released</td>
</tr>
<tr>
<td>Cultural</td>
<td>e.g., hectares of parkland</td>
</tr>
</tbody>
</table>

Look up tables
Biophysical modelling

Valuation

Monetary Services Supply
Level 0: Account 3: Services Supply

- Example (Services Supply in physical units)

<table>
<thead>
<tr>
<th>Ecosystem service</th>
<th>Units</th>
<th>Land cover type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Urban</td>
</tr>
<tr>
<td>Hunting</td>
<td>kg meat</td>
<td>-</td>
</tr>
<tr>
<td>Drinking water extraction</td>
<td>$10^3$ m³ water</td>
<td>4,071</td>
</tr>
<tr>
<td>Crop production</td>
<td>$10^5$ kg produce</td>
<td>-</td>
</tr>
<tr>
<td>Fodder production</td>
<td>$10^5$ kg dry matter</td>
<td>533</td>
</tr>
<tr>
<td>Air quality regulation</td>
<td>$10^5$ kg PM_{2.5}</td>
<td>272</td>
</tr>
<tr>
<td>Carbon sequestration</td>
<td>$10^5$ kg carbon</td>
<td>875</td>
</tr>
<tr>
<td>Cultural</td>
<td>$10^5$ trips</td>
<td>2,690</td>
</tr>
</tbody>
</table>

**Source:** Remme et al., 2014 (Limburg, the Netherlands)
Level 0: Account 3: Services Supply

- What does a Services Supply Account look like?
  - Spatially-detailed physical measures of “final” services according to a common Classification:
    - Provisioning
    - Regulating
    - Cultural
  - Physical measures (crops, flood control, clean drinking water, carbon sequestration, recreation, …)
  - Services supply account in physical terms forms the basis for Valuation where appropriate and available
    - Monetary Services Supply
Level 0: Account 3: Services Supply

- What do you need to create a Services Supply Account?
  - Ecosystem Extent
  - Common spatial infrastructure (Spatial Units)
  - Common Classification of services
  - Data:
    - Field studies
    - Economic production (agriculture, forestry, fisheries, water)
    - Biophysical modelling of individual ecosystem services
  - Expertise: ecologists, geographers (GIS), economists, policy analysts, statisticians
Level 0: Thematic accounts
Thematic Account: Carbon

SEEA-EEA accounts, tools and linkages

1. Ecosystem extent account
2. Ecosystem condition account
3. Ecosystem services supply and use account - physical
4. Ecosystem services supply and use account - monetary
5. Ecosystem monetary asset account

Tools:
- Classifications
- Spatial units, scaling & aggregation
- Biophysical modelling

Thematic accounts:
- Land
- Water
- Carbon
- Biodiversity

Integrated accounts:
- Combined presentations
- Extended supply and use accounts
- Sequence of accounts
- Balance sheets

SEEA
Carbon account: What and Why?

• What?
  • Measurement of carbon stocks and flows for all parts of the carbon cycle and all carbon pools
    • Focus of carbon accounting at this stage is on biocarbon and geocarbon
    • Carbon-related services (sequestration and storage)
    • Carbon as a characteristic of ecosystem condition (productivity)
• Why?
  • Policies on climate change, low-carbon economy
  • Assess changes in land cover and land use on carbon stocks and sequestration
  • Links to other SEEA accounts (Condition, Services Supply)
  • Links to SEEA CF (timber, soil, materials)
  • Links to international guidelines (IPCC and REDD+)
  • Indicators:
    • Natural and human additions to carbon stock ➔ where
    • Natural and human removals from carbon stock ➔ where
What does a carbon stock account look like?

Maps

Removals

Hydrology

Soil

Vegetation

### Tables

<table>
<thead>
<tr>
<th></th>
<th>Geocarbon</th>
<th>Biocarbon</th>
<th>Oceans</th>
<th>Atmosphere</th>
</tr>
</thead>
<tbody>
<tr>
<td>Opening stock</td>
<td>10,000</td>
<td>400</td>
<td>20,000</td>
<td>100</td>
</tr>
<tr>
<td>Additions</td>
<td>-</td>
<td>4</td>
<td>10</td>
<td>24</td>
</tr>
<tr>
<td>Reductions</td>
<td>10</td>
<td>5</td>
<td>9</td>
<td>14</td>
</tr>
<tr>
<td>Closing stock</td>
<td>9,990</td>
<td>399</td>
<td>20,001</td>
<td>110</td>
</tr>
</tbody>
</table>

Scaling Biophysical modelling

Geosphere

Biosphere

Oceans
What does a carbon stock account look like?

- Spatially detailed in terms of:
  - Carbon stocks
  - Additions and reductions
- Natural & human additions and removals

<table>
<thead>
<tr>
<th>Gigagrams Carbon (GgC)</th>
<th>Geocarbon</th>
<th>Biocarbon</th>
<th>Atmosphere</th>
<th>Water in oceans</th>
<th>Accumulation in economy</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Limestone</td>
<td>Oil</td>
<td>Gas</td>
<td>Coal</td>
<td>Other</td>
<td>Inventories*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fixed assets</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Consumer durables</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Waste</td>
</tr>
<tr>
<td>Opening stock of carbon</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additions to stock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural expansion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Managed expansion</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Discoveries</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upward reappraisals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Redifications</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total additions to stock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reductions in stock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural contraction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Managed contraction</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Downward reappraisals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Redifications</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total reductions in stock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Imports and exports</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Imports</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exports</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closing stock of carbon</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Excluding inventories included in biocarbon (e.g., plantation forests, orchards, livestock, etc.).

Note: Dark grey cells are null by definition.
What do you need to compile a carbon account?

- **Ecosystem extent account**
- Common spatial infrastructure (spatial units)
- Lookup tables (sequestration and storage by land cover type)
- **Data:**
  - Biocarbon (above-ground biomass) from satellite data
  - Carbon sequestration and storage from vegetation cover
  - Soil carbon from soil inventories
  - Removals from agriculture, forestry data, fires
- **Expertise:**
  - Ecologists (biophysical modelling)
  - Agriculture, forestry experts
  - Geographers (GIS, remote sensing)
Thematic Account: Biodiversity

SEEA-EEA accounts, tools and linkages

1. Ecosystem extent account
2. Ecosystem condition account
3. Ecosystem services supply and use account - physical
4. Ecosystem services supply and use account - monetary
5. Ecosystem monetary asset account

Tools:
- Classifications
- Spatial units, scaling & aggregation
- Biophysical modelling
- Valuation techniques

Integrated accounts:
- Combined presentations
- Extended supply and use accounts
- Sequence of accounts
- Balance sheets

Thematic accounts:
- Land
- Water
- Carbon
- Biodiversity
Biodiversity accounting: What?

- **What do biodiversity accounts contain?**
  - Biodiversity information linked to areas of ecosystems (from *extent account*)
  - Spatially detailed information on key species:
    - Abundance
    - Richness
    - Conservation status
    - Other characteristics (e.g. health)
  - Spatially detailed summary statistics (index) on species diversity (used in *condition account*)
Biodiversity accounting: Why?

• **Why would you create biodiversity accounts?**
  
  • To compare trends in biodiversity with economic and social activity in a spatially explicit manner
  
  • To link biodiversity information with other SEEA accounts (condition, services supply)
  
  • To meet global commitments under the Convention on Biological Diversity’s Strategic Plan for Biodiversity (2011-2020)
  
  • To support sustainable development
What does a biodiversity account look like?

Maps

- Ecosystems
- Species 3
- Species 2
- Species 1

Tables

<table>
<thead>
<tr>
<th>Priority species and ecosystems</th>
<th>Species 1</th>
<th>Species 2</th>
<th>Species 3</th>
<th>Species ...</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opening</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Net change</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Species data:
- abundance
- richness
- classification
- conservation status
- characteristics
- health
Biodiversity account: requirements

- **What do you need to produce a biodiversity account?**
  - The key policy questions & goal of the biodiversity account
  - List of key or priority species
  - List of data sources (e.g., national, global) supported by a dialogue with data providers to ascertain data availability.
  - Expertise to mobilise data and plug data gaps:
    - Species measurement
    - Biophysical modelling, GIS
    - Indicator development
    - Statistical analysis
Biodiversity account: requirements

• **What do you need to produce a biodiversity account?**
  - Information on key or priority species
    - Species classifications (family, genus)
    - Species measures (ranges, richness, population counts over time)
    - Characteristics (e.g., habitat, specialist/generalist, health)
    - Conservation status
  - **Extent account** or some form of spatial infrastructure for ecosystems
    (spatial units)
Level 0: Integrated accounts
Integrated accounts
Four broad types of integrated accounts:

- Combined presentations
- Extended supply and use accounts
- Sequence of accounts
- Balance sheets (extended measures of wealth)
Combined presentations

- Tables that support the presentation of information from a variety of sources in a manner that facilitates comparison between economic and environmental data.
  > Possible because of common classifications and accounting principles.
  > Well-known is decoupling graphs, indicators on resource productivity / intensity

- Two examples in ecosystem accounting:
  > (i) combine changes in condition with expenditure on environmental protection on those assets; and
  > (ii) information on flows of ecosystem services generated by an ecosystem asset combined with information on economic activity associated with that asset
Extended supply and use accounts

• Augmented SUA present information on the supply and use of ecosystem services as extensions to the standard SNA SUA.
  > Ecosystem accounting -> extension to the production boundary
  > Additional rows for ES (as set of products within scope of the SUA is broader and hence the size)
  > Additional columns (as ecosystem assets considered additional producing units)

• Environmentally-extended input-output tables (EE-IOT).
  > Requires information on environmental flows classified and structured as for the standard input-output data.
  > Matrix algebra (Leontief inverse) -> consumption based indicators (e.g. Carbon or biodiversity footprints / embodied water)

• IO tables are regularly compiled (national and multi-regional)
Sequence of accounts (SNA) provide a complete overview of all economic transactions:

> Current accounts (production, income, savings)
> Capital accounts
> Balance sheets

- Focus on the institutional sector level (i.e. corporations, governments, households)
- Full suite of indicators (income, saving, investment and wealth)
- **Integrated sequence of institutional sector accounts**
  > Environmentally adjusted aggregates (depletion or degradation adjusted NDP (“green GDP”))
Balance sheets

Balance sheets: record all assets and liabilities of country (by institutional sector) and changes during accounting period

- The integration of ecosystem asset -> extended measures of wealth (wealth accounting)

- Issues:
  - avoid double counting with existing values for natural resources, such as timber and fish
  - in many countries value of land already recorded on the SNA balance sheet in terms of its market price (but may not capture all ecosystem services)
  - Ecosystems that provide intermediate (or supporting services)
End of Accounts...

Questions?

Discussion

• Prepare for group exercise...think about:
  > What are your priority accounts?
  > What are the opportunities to produce them?
    - Stakeholders?
    - Institutional mechanisms?
    - Current activities?
  > What are the constraints?
    - Data?
    - Capacity?

• Next up: Tools
Level 0: Tools
Level 0: Tools

- Classifications
- Spatial units, scaling & aggregation
- Biophysical modelling
- Valuation
- Other tools:
  - Statistical quality guidelines
  - Interdisciplinary teams
  - Case studies and surveys
- Not discussed: GIS (spatial analysis), data analysis, communications, engagement, data management, project planning and evaluation...
Tools 1: Classifications

SEEA-EEA accounts, tools and linkages

1. Ecosystem extent account
2. Ecosystem condition account
3. Ecosystem services supply and use account - physical
4. Ecosystem services supply and use account - monetary
5. Ecosystem monetary asset account

Tools: Classification, spatial units, scaling & aggregation, biophysical modelling

Tools: Valuation techniques

Integrated accounts
- Combined presentations
- Extended supply and use accounts
- Sequence of accounts
- Balance sheets

Thematic accounts
- Land
- Water
- Carbon
- Biodiversity

SEEA
Level 0: Tools 1: Classifications

• What?
  > From SEEA-CF:
    - Land cover, land use
    - Economic units, industry sectors
  > New:
    - Final ecosystem services

• Why:
  > Accounting needs Consistent and Coherent and Comprehensive Classifications
    - Consistent: use same classification for same concept
    - Coherent: with other classification
    - Comprehensive: Classifications Certify Complete Coverage
# Level 0: Tools 1: Classifications

## Land Cover

- From SEEA-CF (p.276)
- Uses FAO LCCS 3 (Food and Agriculture Organization – Land Cover Classification System v3) definitions
- High-level aggregate
- May adapt to local situations
- Used as basis for ecosystem type

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Artificial surfaces (including urban and associated areas)</td>
</tr>
<tr>
<td>02</td>
<td>Herbaceous crops</td>
</tr>
<tr>
<td>03</td>
<td>Woody crops</td>
</tr>
<tr>
<td>04</td>
<td>Multiple or layered crops</td>
</tr>
<tr>
<td>05</td>
<td>Grassland</td>
</tr>
<tr>
<td>06</td>
<td>Tree covered areas</td>
</tr>
<tr>
<td>07</td>
<td>Mangroves</td>
</tr>
<tr>
<td>08</td>
<td>Shrub covered areas</td>
</tr>
<tr>
<td>09</td>
<td>Shrubs and/or herbaceous vegetation, aquatic or regularly flooded</td>
</tr>
<tr>
<td>10</td>
<td>Sparsely natural vegetated areas</td>
</tr>
<tr>
<td>11</td>
<td>Terrestrial barren land</td>
</tr>
<tr>
<td>12</td>
<td>Permanent snow and glaciers</td>
</tr>
<tr>
<td>13</td>
<td>Inland water bodies</td>
</tr>
<tr>
<td>14</td>
<td>Coastal water bodies and inter-tidal areas</td>
</tr>
</tbody>
</table>
Level 0: Tools 1: Classifications

1.0 Land
- 1.1 Agriculture
- 1.2 Forestry
- 1.3 Aquaculture
- 1.4 Built up and related areas
- 1.5 Maintenance and restoration of environmental functions
- 1.6 Other uses of land
- 1.7 Land not in use

2.0 Inland waters
- 2.1 Aquaculture and holding facilities
- 2.2 Maintenance and restoration of environmental functions
- 2.3 Other uses of inland waters
- 2.4 Inland waters not in use

3.0 Coastal waters
- 3.1 Aquaculture and holding facilities
- 3.2 Maintenance and restoration of environmental functions
- 3.3 Other uses of coastal waters
- 3.4 Coastal waters not in use

4.0 Exclusive Economic Zone (EEZ)
- 4.1 Aquaculture and holding facilities
- 4.2 Maintenance and restoration of environmental functions
- 4.3 Other uses of coastal waters
- 4.4 Coastal waters not in use
Level 0: Tools 1: Classifications

Services

- Based on Common International Classification of Ecosystem Services (CICES)
- Not mutually exclusive
- A list of “final” services
- More detail (4-digit)
- Does not include “supporting services” (= ecosystem functions)
Level 0: Tools 1: Classifications

• From SEEA-CF: Economic Units
  > Enterprises (business © industry)
  > Households (people and non-corporate business)
  > Government
  > Rest of the world

• SEEA-EEA adds a spatial dimension:
  > Local
  > Regional
  > National
  > Global
Tools 2: Spatial Units

SEEA-EEA accounts, tools and linkages

1. Ecosystem extent account
2. Ecosystem condition account
3. Ecosystem services supply and use account - physical
4. Ecosystem services supply and use account - monetary
5. Ecosystem monetary asset account

Tools: Classifications, Spatial units, Scaling, Aggregation, Biophysical modelling

Tools: Valuation techniques

Ecosystem capacity

Accounts in physical terms

Accounts in monetary terms

Integrated accounts
- Combined presentations
- Extended supply and use accounts
- Sequence of accounts
- Balance sheets

Thematic accounts
- Land
- Water
- Carbon
- Biodiversity

SEEA
Level 0: Tools 2: Spatial units

- **What?**
  - A common definition of Spatial Units for all accounts

- **Why?**
  - Accounting needs **statistical units** about which information is compiled, derived, reported and compared
    - e.g., business statistics are built on locations, establishments, companies and enterprises
  - Information is collected on many **spatial levels**
    - Needs to be consolidated within a GIS or spatial model
  - First step in **tabulating & aggregating** more detailed data
    - Not everybody is a GIS expert
  - Links accounts together:
    - *(Extent, Condition, Services Supply...)*
Level 0: Tools 2: Spatial units

4 types of units
- Basic spatial units (BSU)
- Ecosystem asset (EA)
- Ecosystem type (ET)
- Ecosystem Accounting Area (EAA)
Level 0: Tools 2: Scaling

• What?
  > Converting information from one scale to another (spatial, temporal, thematic)

• Why?
  > Information exists in various types:
    - Point (water quality monitoring, “study sites”, etc.)
    - Area (land cover, protected area, species range, etc.)
    - Network (roads, streams, corridors, etc.)
  > Need to understand how and when to attribute information from one scale to another
Level 0: Tools 2: Scaling

• Main approaches
  > Downscaling
    - Attributing information from larger areas to smaller areas contained within them
    - **Caution**: Data need to be evenly distributed
  > Upscaling
    - Attributing information from smaller areas to larger areas
    - **Caution**: Data need to be representative
  > Transfer
    - Transferring information measured in one location to another
    - Often used in terms of **Benefits Transfer**
    - **Caution**: Locations need to be very similar
Level 0: Tools 2: Aggregation

• **What?**
  > Combining many measures into simpler ones
  > Dissimilar measures may be aggregated using:
    - Indices (e.g., water quality index)
    - Conversion to common units (e.g., CO₂ equivalents)

• **Why?**
  > Accounting requires **aggregates** (of dollars, business types, sub-populations, regional summaries, national indicators...)
  > Summary indicators for dashboards, linking to economic accounts
Level 0: Tools 2: Aggregation

- **Aggregating dissimilar biophysical measures:**
  - Requires indexing (comparison with reference)
  - Example: ecosystem condition measures, service measures
  - **Caution:** Requires understanding of relative importance of component measures (weighting)

- **Final aggregates**
  - e.g., total value of ecosystem services, total asset value
  - Require many assumptions (relative importance, methods...)
  - Services can be competing, complementary or independent
  - **Caution:** Monetary valuation is often applied inappropriately
  - ∴ **Valuation** results can be misleading
Tools 3: Biophysical modelling

SEEA-EEA accounts, tools and linkages

1. Ecosystem extent account
2. Ecosystem condition account
3. Ecosystem services supply and use account - physical
4. Ecosystem services supply and use account - monetary
5. Ecosystem monetary asset account

Integrated accounts:
- Combined presentations
- Extended supply and use accounts
- Sequence of accounts
- Balance sheets

Tools:
- Classifications
- Spatial units
- Scaling
- Aggregation
- Biophysical modelling

Thematic accounts:
- Land
- Water
- Carbon
- Biodiversity
Level 0: Tools 3: Biophysical modelling

• What?
  > Four main approaches:

• Why?
  > 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

1. Look-up tables
2. Statistical approaches
3. Geostatistical interpolation
4. Process-based modelling
Level 0: Tools 3: 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: 60-70%
Level 0: Tools 3: 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 = 40-50%
Level 0: Tools 3: 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 = ?
Level 0: Tools 3: 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 = 100%
Level O: Valuation
Tools 4: Valuation

SEEA-EEA accounts, tools and linkages

1. Ecosystem extent account
2. Ecosystem condition account
3. Ecosystem services supply and use account - physical
4. Ecosystem services supply and use account - monetary
5. Ecosystem monetary asset account

_tools: Valuation techniques_

_tools: Classifications, Spatial units, scaling & aggregation, Biophysical modelling_

Thematic accounts
- Land
- Water
- Carbon
- Biodiversity

Integrated accounts
- Combined presentations
- Extended supply and use accounts
- Sequence of accounts
- Balance sheets
Level 0: Tools 4: Valuation

- Why value?
  - To integrate environmental issues in economic decision making and development planning

- Valuation is fit for purpose:
  - Different contexts require different value concepts

- Assessment of welfare:
  - E.g. cost benefit analysis, focus on utility

- Assessment of economic activity:
  - E.g. National accounts, focus on exchange value

- Other notions of value:
  - Intrinsic value
  - Critical value / strong sustainability
Level 0: Tools 4: Valuation

Object of valuation, what do we value?

Stocks and flows: natural capital conceived as asset (stock) that provides a basket of services (flows)

- Ecosystem services
  > Flows: during the year

- Ecosystem capital
  > Assets: value at beginning/end of year and changes therein

- Degradation of ecosystems
  > The decline in the condition of ecosystem assets as a result of economic and other human activity.
Level 0: Tools 4: Valuation

How do we value?

• Range of valuation techniques exist

• SEEA EEA is multipurpose system that does not rule out a priori any techniques, BUT advocates consistency when integrating with existing values

• National accounts is a transaction based system:
  > SUPPLY = USE
  > Rules out consumer surplus and externalities

• When integrating into national accounts -> estimating exchange values
Level 0: Tools 4: Valuation

• Measurement challenges
  > More challenging for Regulating and Cultural Services
  > How to measure monetary value of regulating services?
    - Spatial dependencies (downstream, species/habitat)
    - Multiple beneficiaries
    - Risks (e.g., flood control, climate regulation)
  > Non-linear responses
    - Thresholds/resilience, climate change, refuge areas
  > Aggregating values of different services
    - Services can be competing, complementary or independent
  > Transferring measured values from one site to another
    - (Discussed under Biophysical Modelling & Scaling)
Tools 5: Other tools

SEEA-EEA accounts, tools and linkages

1. Ecosystem extent account
2. Ecosystem condition account
3. Ecosystem services supply and use account - physical
4. Ecosystem services supply and use account - monetary
5. Ecosystem monetary asset account

Tools: Classifications, Spatial units, scaling & aggregation, Biophysical modelling

Thematic accounts:
- Land
- Water
- Carbon
- Biodiversity

Integrated accounts:
- Combined presentations
- Extended supply and use accounts
- Sequence of accounts
- Balance sheets
Level 0: Tools 5: Other tools

• What?
  > Statistical quality guidelines

• Why?
  > Need a common concept of quality, uncertainty and “fitness for use”

• How?
  > Apply national or international guidelines
    - UN National Quality Assurance Framework (NQAF)
    - International Monetary Fund – Data Quality Assessment Framework (IMF-DQAF)
    - Disciplinary “accepted methods” are less-well documented
  > Build a culture of quality:
    - Metadata, process documentation, strategic planning…
  > Work within accepted statistical processes (e.g., Generic Statistical Business Processing Model – GSBPM)
Level 0: Tools 5: Other tools

• What?
  > **Interdisciplinary teams** (ecology, economics, geography, policy, sociology, statistics…)

• Why?
  > **No single** discipline can do it alone
    → Need a shared “language”
    → Need to become **transdisciplinary**

• How?
  > Agree on common objectives and approaches
  > Work together to avoid disciplinary “stovepipes”
  > Engage experts, data providers, users and supporters
Level 0: Tools 5: Other tools

• What?
  > **Case studies & surveys** linking services with benefits

• Why?
  > In some countries, there is a close relationship between ecosystem services and poverty, water security, food security, employment…
  > Link ecosystem condition, services with socio-economic priorities (well-being, health, income, employment…)

• How?
  > Local surveys for priority stakeholders (e.g., dependent on ecosystem services)
  > National sample surveys (e.g., water use, importance of nature, expenditures on environmental protection…)

87

SEEA
References

- SNA 2008
- SEEA Central Framework, SEEA-EEA, Applications and Extensions
- SCBD Quick Start Package
- World Bank WAVES: Designing Pilots for Ecosystem Accounting
- International Monetary Fund: DQAF
- UN: NQAF
- UNECE: GSBPM


Acknowledgements

These materials have been developed in partnership with various organizations including the United Nations Statistics Division, UN Environment, the Convention on Biological Diversity, supported by the Norwegian Ministry of Foreign Affairs, and the European Union.