Key Concepts = “Level 0”

Project: Advancing the SEEA
Experimental Ecosystem Accounting

United Nations
UNEP
Convention on Biological Diversity
NORWEGIAN MINISTRY OF FOREIGN AFFAIRS

Overview

1. **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

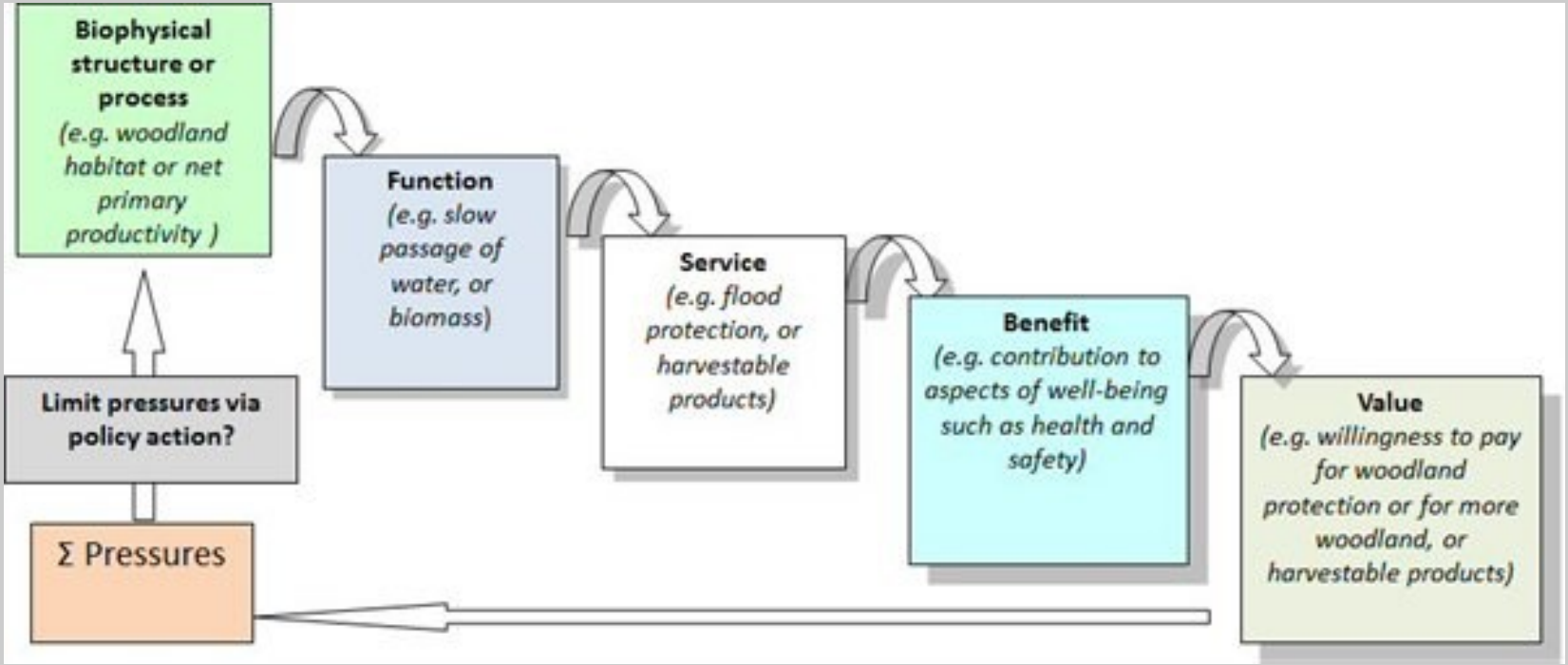
- **Basic concepts and definitions**
  - Ecosystems as “Assets”
  - The Ecosystem Services “Cascade”
    - Ecosystem structure and processes, function, services, benefits and values
  - Accounting (not just “counting”) Principles
    - Assets, stocks and flows
    - Balancing the books
  - Ecosystem 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



Source: Nottingham School of Geography

- **Ecosystem services** are the contribution of ecosystems to a benefit for people…

Accounting principles…

- **Apply to environmental data, too…**
  - **Double entry accounting**:
    - Beginning & end of time period → reconcile changes
    - Compare two sources → 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 → Flow (Asset → Service)**

Balancing the books of environmental assets

Time 1

Assets

Regeneration

Services

Economy and well-being

Waste & degradation

Balancing the books of environmental assets

Time 2

Assets

Services

Economy and well-being

Regeneration

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 depends 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.

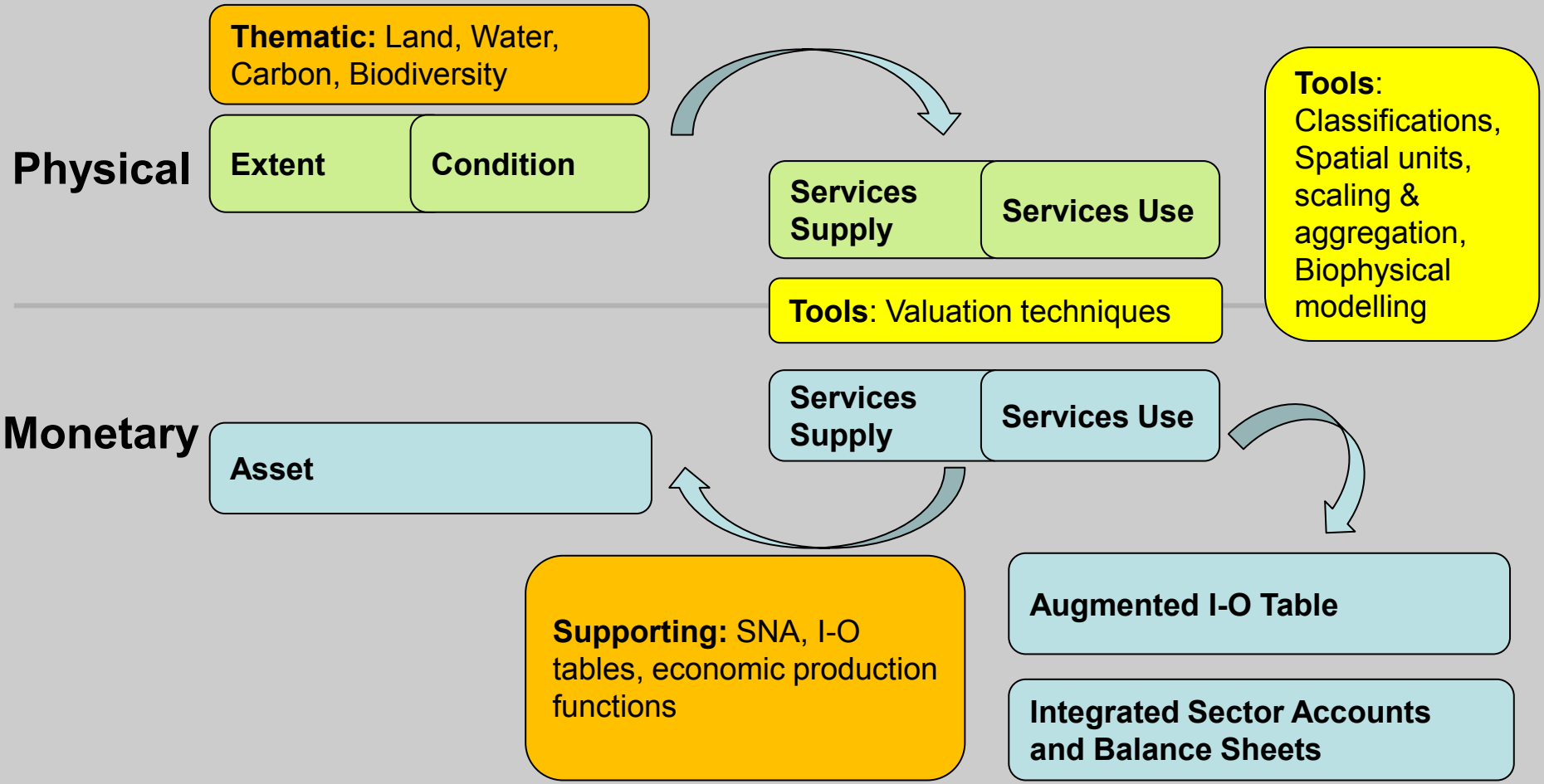
Ecosystem accounting is spatial

- 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



SEEA-EEA Accounts and Tools

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

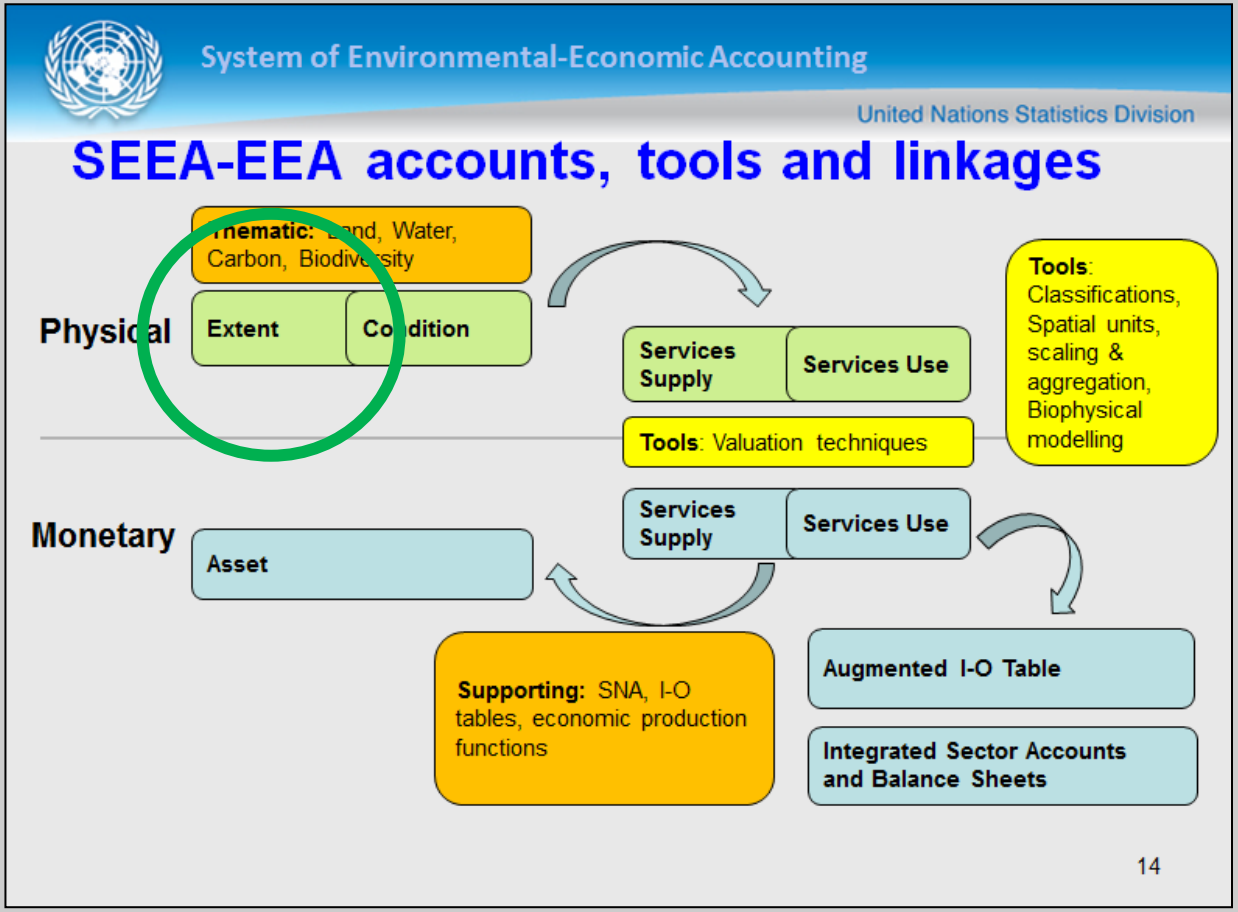
Accounts

- Ecosystem Extent Account
- Ecosystem Condition Account
- Thematic Accounts:
  - Water Account
  - Carbon Account
  - Biodiversity Account
- Ecosystem Services Supply Account
- Ecosystem Services Use Account
- Ecosystem Capacity
- Augmented I-O Tables
- Integrated Sector Accounts and Balance Sheet
- Supporting information

Tools

- Classifications
- Spatial units, scaling and aggregation
- Biophysical modelling
- Valuation

Account 1: Extent



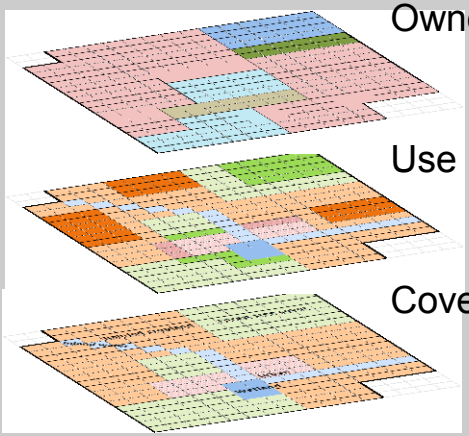
Level 0: Account 1: Extent

- **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 land cover, land use, ownership (terrestrial, freshwater, coastal and marine areas)
- **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



Tables

Cover	Urban and associated		Rainfed herbaceous cropland		Forest tree cover		Inland water bodies		Open wetlands	Total
Use	Infrastructure	Residential	Permananet crops	Maintenance	Forestry	Protected	Infrastructure	Aquaculture	Maintenance	
Ownership	Government	Private	Private	Private	Private	Government	Government	Private	Government	
Units	hectares									
Opening Stock										
Additions to Stock										
Managed expansion										
Natural expansion										
Reductions to stock										
Managed regression										
Natural regression										
Closing stock										

Spatial units
Classifications

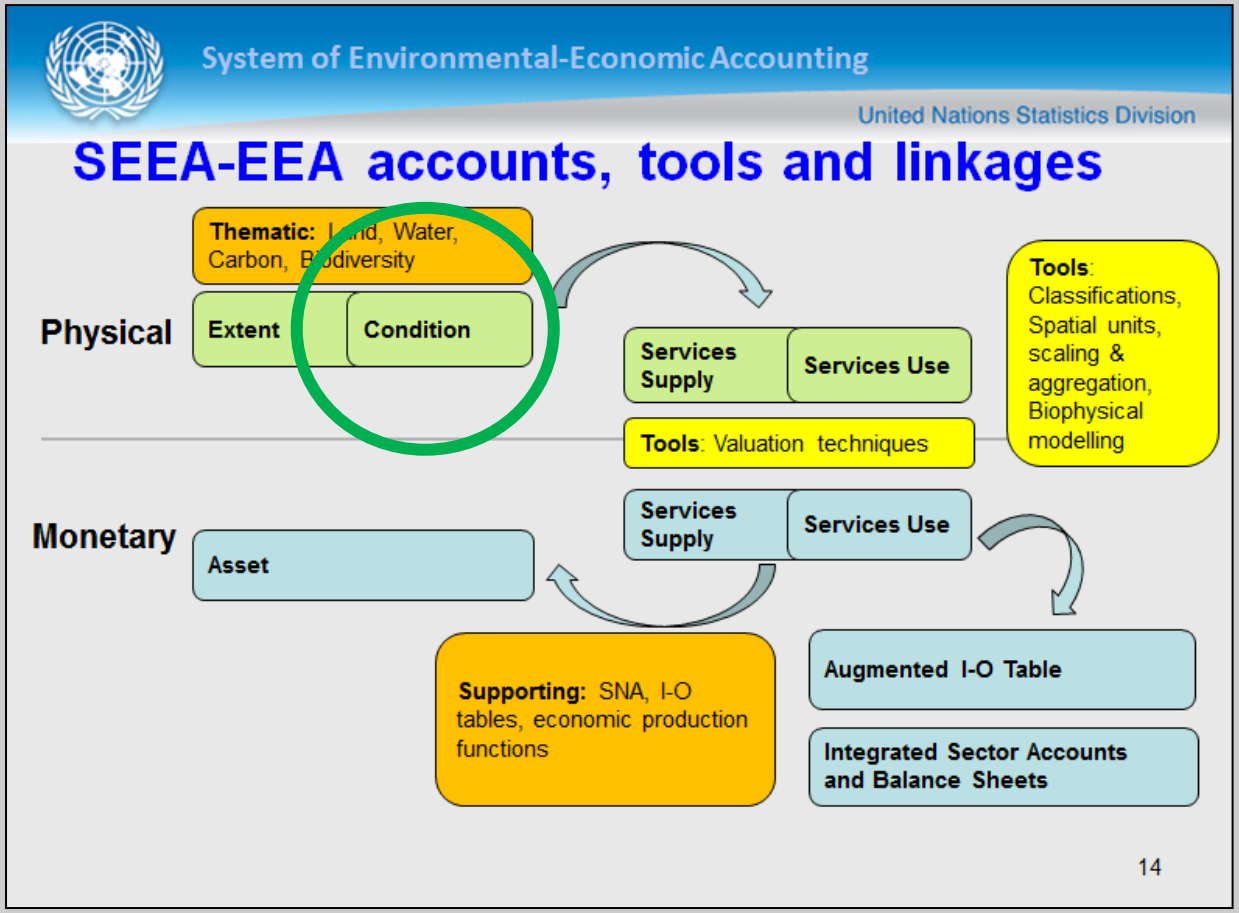
Level 0: Account 1: Extent

- **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)

Account 2: Condition



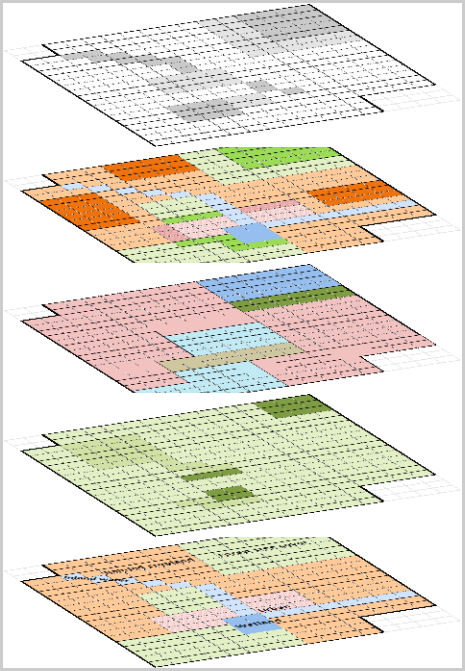
Level 0: Account 2: Condition

- **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



Tables

Ecosystem type	Ecosystem extent (ha)	Ecosystem condition					
		Vegetation biomass (tonnes)	Biodiversity Index	Soil Organic matter	Water Quality Index	Carbon Balance	Index
Urban and associated							
Rainfed herbaceous cropland							
Forest tree cover							
Inland water bodies							
Open wetlands							

Scaling & aggregation

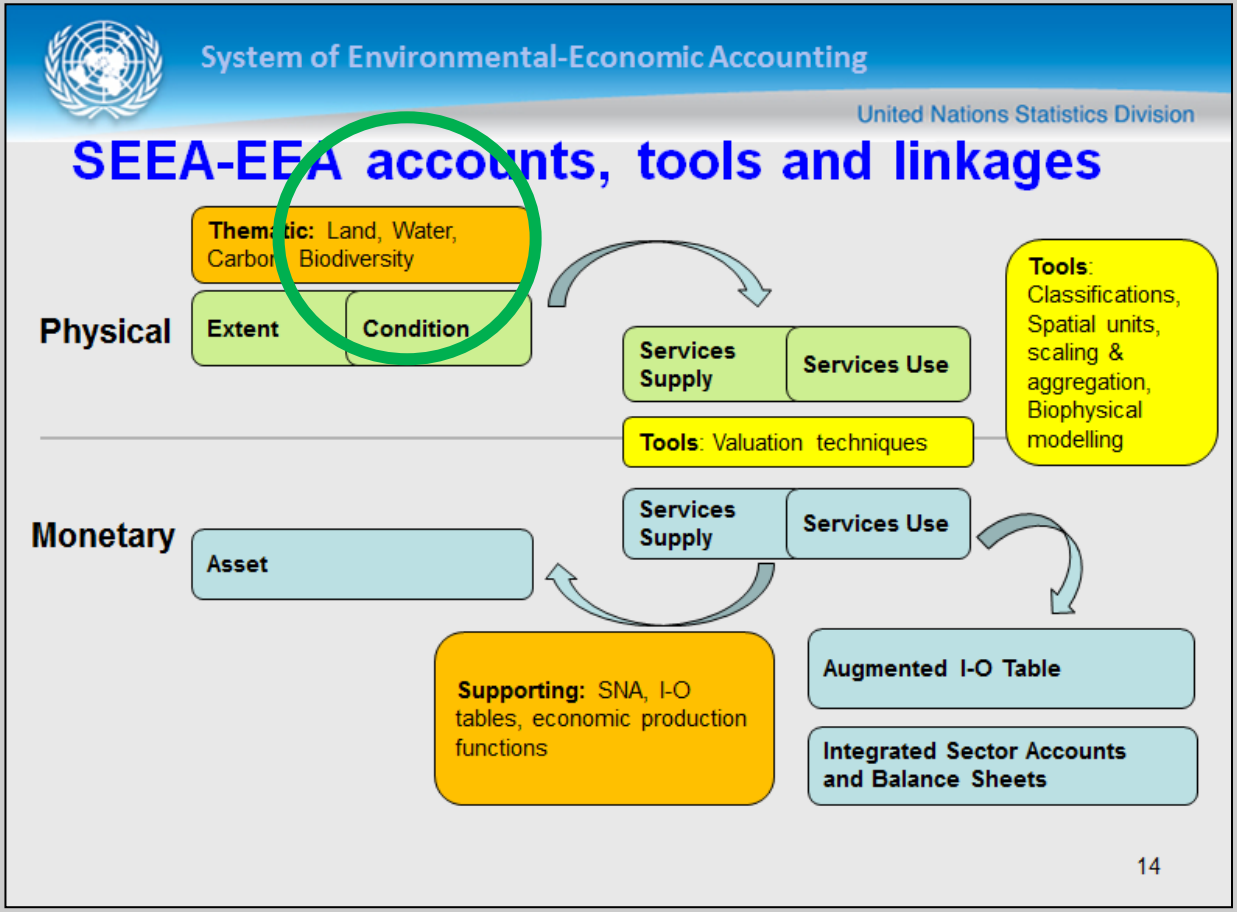
Level 0: Account 2: Condition

- **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)

Account 3: Water



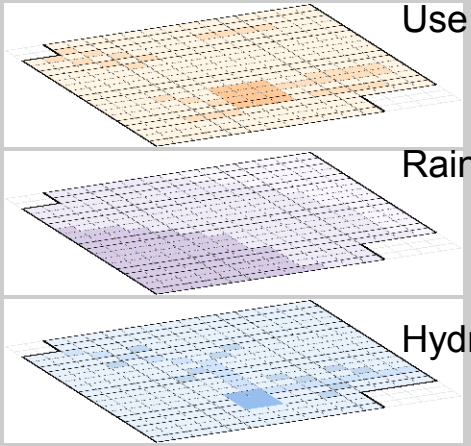
Level 0: Account 3: Water

- **What?**
  - Spatially-detailed version of SEEA-CF Water Account to capture:
    - Inter-ecosystem flows of water (SEEA-EEA 4.62),
    - Water quality and
    - Supply/use for ecosystems
- **Why?**
  - Policies on water security, water quality, impacts of water abstraction on ecosystems
  - Links to other accounts (**Condition**, **Services Supply & Use**)
  - Links to SEEA-CF; SEEA-WATER
  - Indicators:
    - Local water supply/use, quality (use > supply?)
    - Variability in supply, trends (droughts, floods)

Level 0: Account 3: Water

- **What does a Water Account look like?**

Maps



Tables

	Use of water							
	Agriculture, forestry and fishing	Mining & quarrying, manufacturing and construction	Electricity, gas, steam and air conditioning supply	Water collection, treatment and supply	Sewerage	Other industries	Households	**Total use**
	millions m^3							
Source of abstracted water								
Inland water resources								
Surface water								
Goundwater								
Soil water								
Total								
Other water sources								
Precipitation								
Sea water								
Total								
Total use of abstracted water								
Abstracted water								
Distributed water								
Own use								

Spatial units
Classifications
Biophysical modelling
Socio-economic data

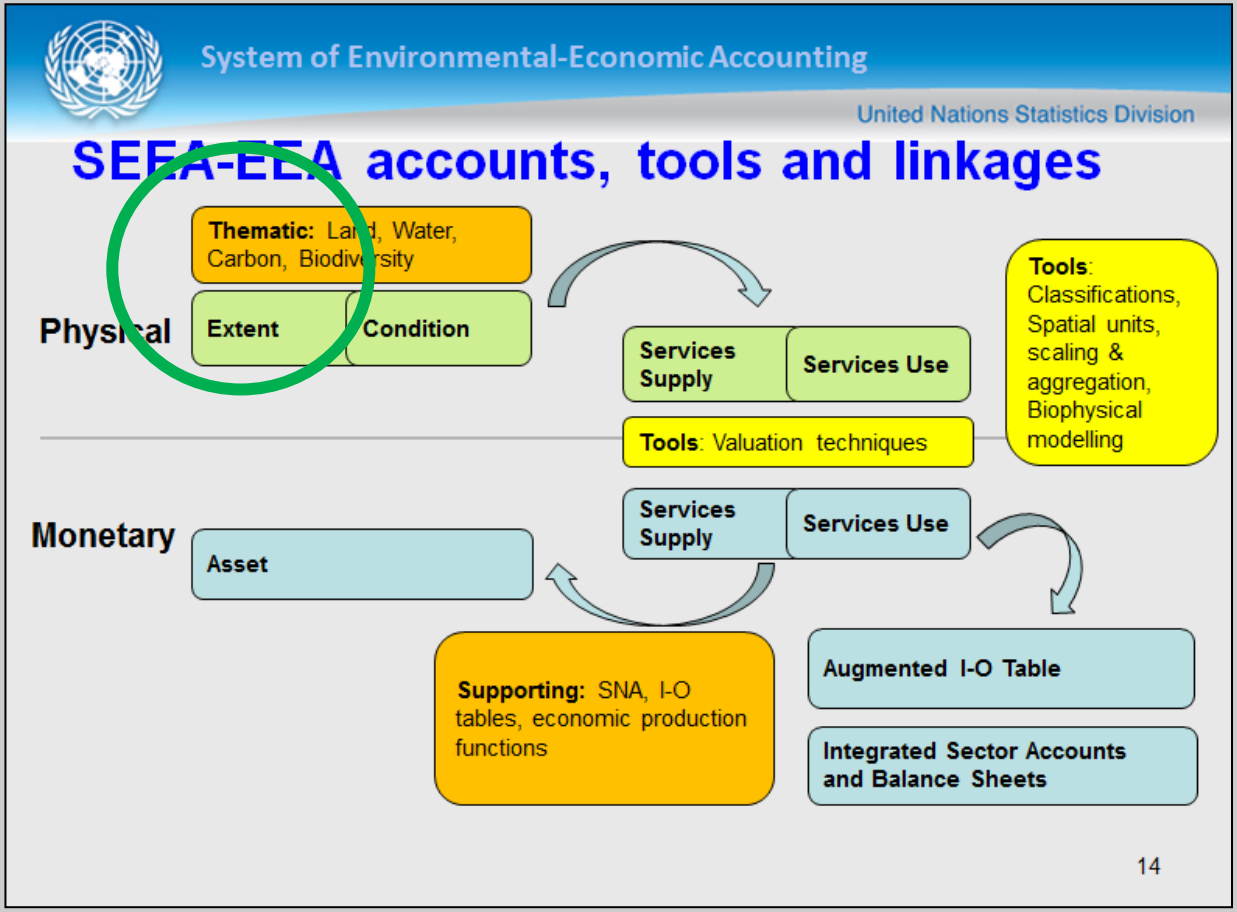
Level 0: Account 3: Water

- **What does a Water Account look like?**
  - Spatially-detailed data on:
    - Stock
    - Supply, and
    - Use including soil moisture & groundwater
  - Water quality measures (contribution to **Condition Account**)

Level 0: Account 3: Water

- **What do you need to compile a Water Account?**
  - Ecosystem Extent Account
  - SEEA-CF Water Account (national level)
  - Common spatial infrastructure (Spatial Units)
  - **Data:**
    - Spatially-detailed supply (rainfall, transfers)
    - Use (abstraction, inter-ecosystem transfers);
    - Water quality measures
  - **Expertise:**
    - Geographers (GIS and remote sensing)
    - Hydrologists
    - Ecologists
    - Climatologists

Account 4: Carbon



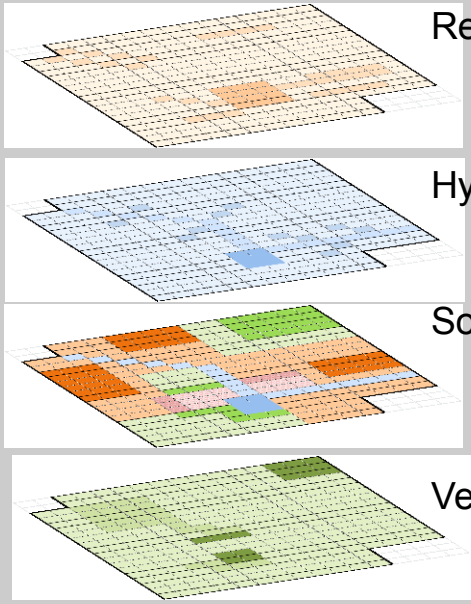
Level 0: Account 4: Carbon

- **What?**
  - Accounts for **biocarbon** as an asset (e.g., soil carbon)
  - 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

Level 0: Account 4: Carbon

- **What does a Carbon Account look like?**

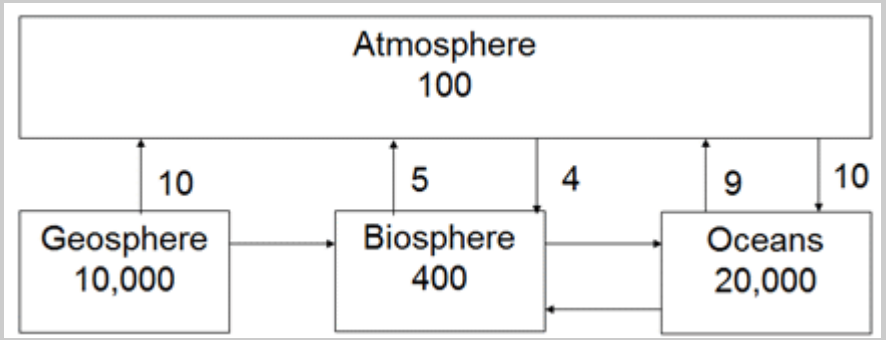
Maps



Tables

	Geocarbon	Biocarbon	Oceans	Atmosphere
	billion tonnes C			
Opening stock	10,000	400	20,000	100
Additions	-	4	10	24
Reductions	10	5	9	14
Closing stock	9,990	399	20,001	110

Scaling
Biophysical modelling



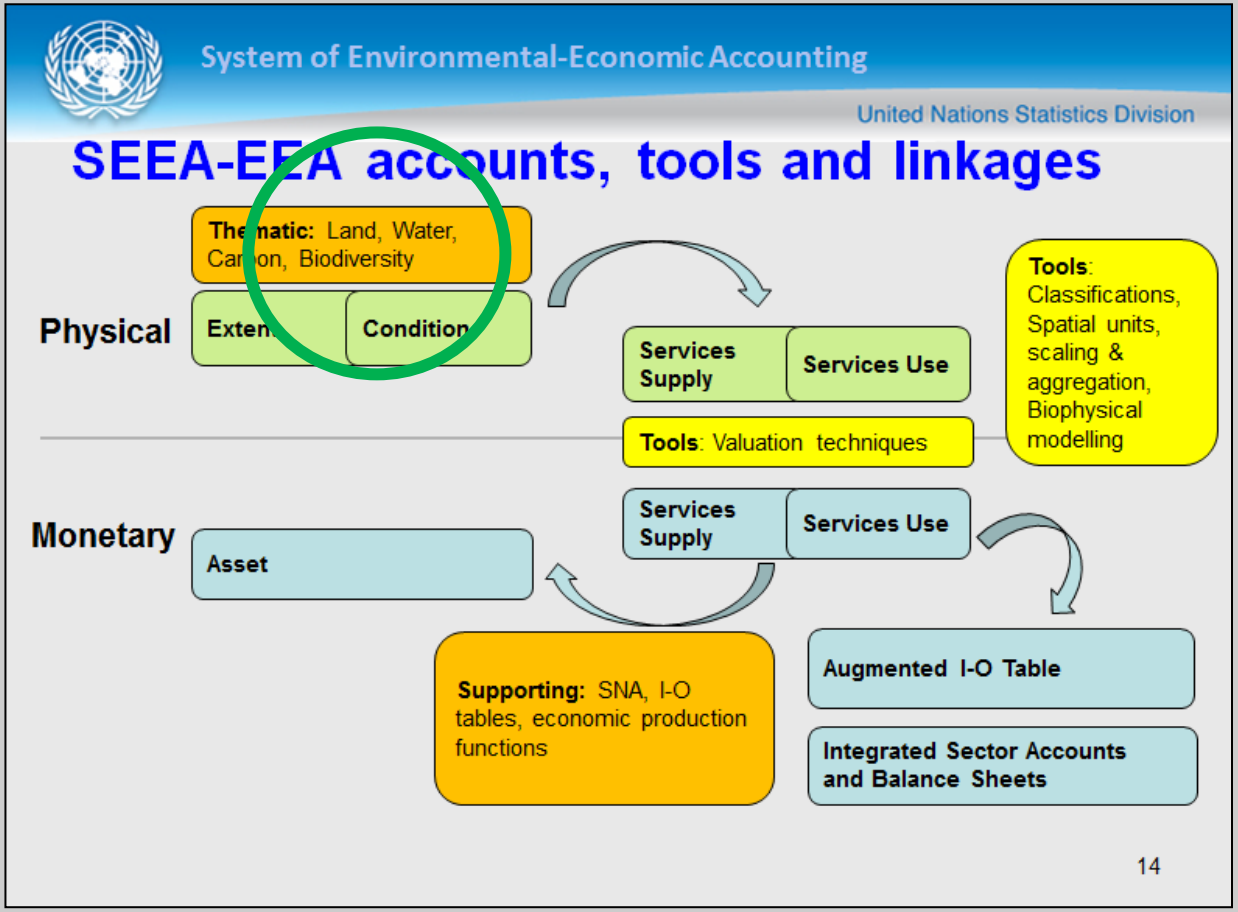
Level 0: Account 4: Carbon

- **What does a Carbon Account look like?**
  - Spatially detailed in terms of:
    - Stock
    - Additions and reductions of **biocarbon**
  - Natural & human additions and removals

Level 0: Account 4: Carbon

- **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)

Account 5: Biodiversity



Level 0: Account 5: Biodiversity

- **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)

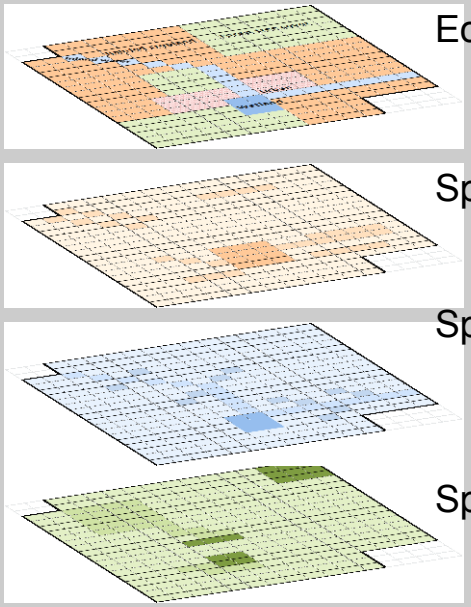
Level 0: Account 5: Biodiversity

- **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, Ecosystem Services Generation)
  - To meet global commitments under the Convention on Biological Diversity's Strategic Plan for Biodiversity (2011-2020)
  - To support sustainable development

Level 0: Account 5: Biodiversity

- **What does a Biodiversity Account look like?**

Maps



Tables

	Priority species and ecosystems								Index
	Species 1		Species 2		Species 1		Species 2		
	Pop.	Ecosys. Area	Pop.	Ecosys. Area	Pop.	Ecosys. Area	Pop.	Ecosys. Area	
Reference									
Opening									
Closing									
Net change									

Species data:
- abundance
- richness
- classification
- conservation status
- characteristics
- health

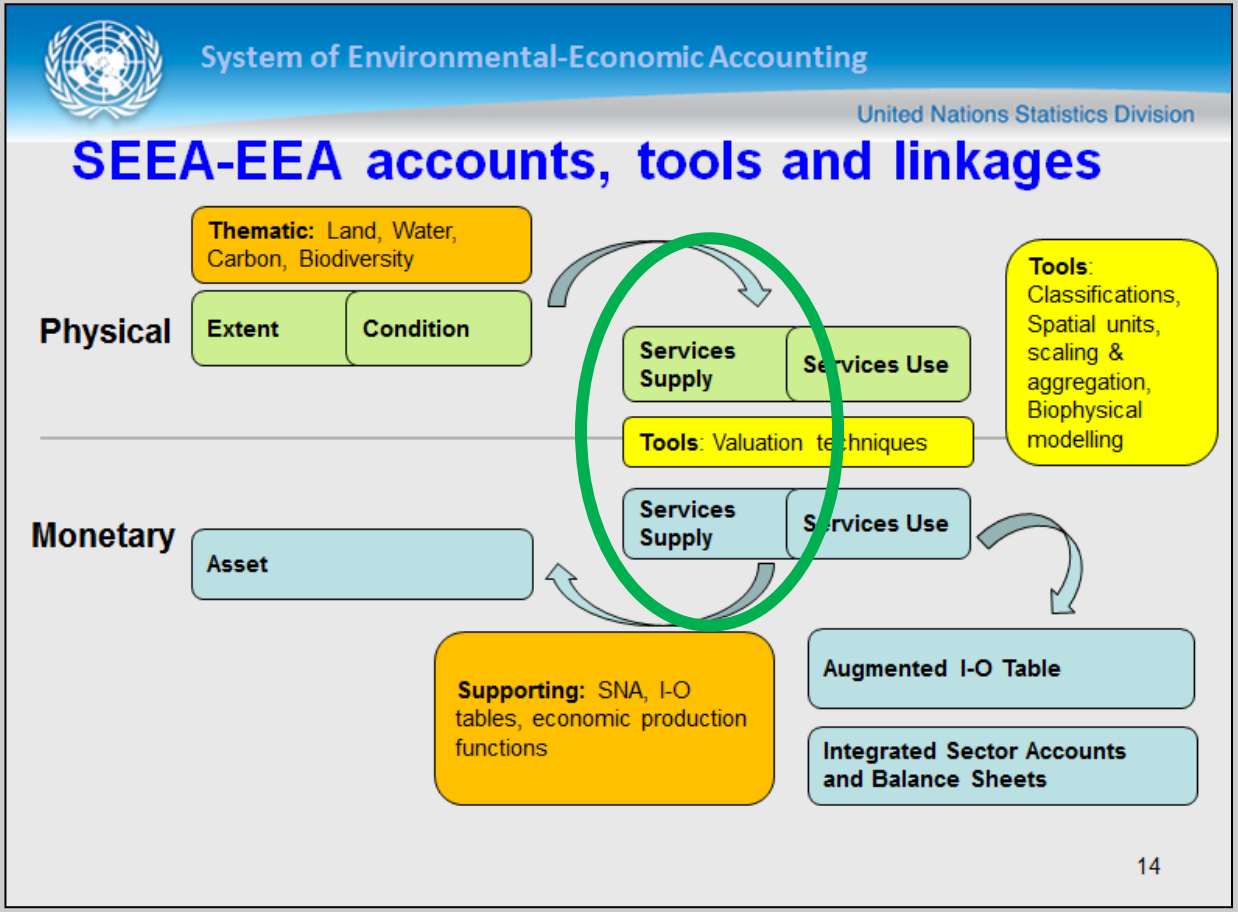
Level 0: Account 5: Biodiversity

- **What do you need to be able 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

Level 0: Account 5: Biodiversity

- **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)

Account 6: Services Supply



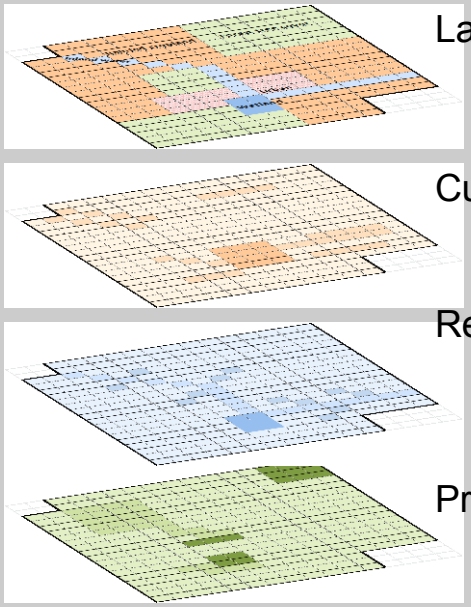
Level 0: Account 6: Services Supply

- **What?**
  - Physical and monetary 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 Asset** valuation)
  - Indicators:
    - Flows of individual services (physical and monetary) ➔ change
    - Indices of aggregated services by ecosystem type ➔ change

Level 0: Account 6: Services Supply

- **What does a Services Supply Account look like?**

Maps



Land cover

Cultural

Regulating

Provisioning

Tables

	Ecosystem type			
Type of service	Urban and associated	Forest tree cover	Agricultural land	Open wetlands
Provisioning		e.g., tonnes of timber	e.g., tonnes of wheat	
Regulating	e.g., tonnes of CO_2 stored / released	e.g., tonnes of CO_2 stored / released	e.g., tonnes of CO_2 stored / released	e.g., tonnes of P absorbed
Cultural	e.g., hectares of parkland	e.g., number of visitors / hikers		e.g., hectares of duck habitat

Lookup tables
Biophysical modelling

Valuation

Monetary Services Supply

Level 0: Account 6: Services Supply

- **Example (Services Supply in physical units)**

Ecosystem service		Units	Land cover type								
			Urban	Pasture	Cropland	Forest	Heath	Peat	Surface Water	Other nature	**Provincial total**
Provisioning	Hunting	kg meat	-	9,100	14,732	8,100	678	70		1,513	**34,193**
	Drinking water extraction	10^3 m^3 water	4,071	7,026	11,227	3,117	214	-	478	862	**26,995**
	Crop production	10^6 kg produce	-	-	1,868	-	-	-	-	-	**1,868**
	Fodder production	10^6 kg dry matter		533	251						**784**
Regulation	Air quality regulation	10^3 kg PM_{10}	272	404	717	700	45	7	40	69	**2,254**
	Carbon sequestration	10^6 kg carbon	875	8,019	273	50,664	393	149	-	1,056	**61,429**
Cultural	Recreational cycling	10^3 trips	2,690	1,863	2,611	1,565	30	3	139	220	**9,121**

Source: Remme et al., 2014 (Limburg, the Netherlands)

Level 0: Account 6: Services Supply

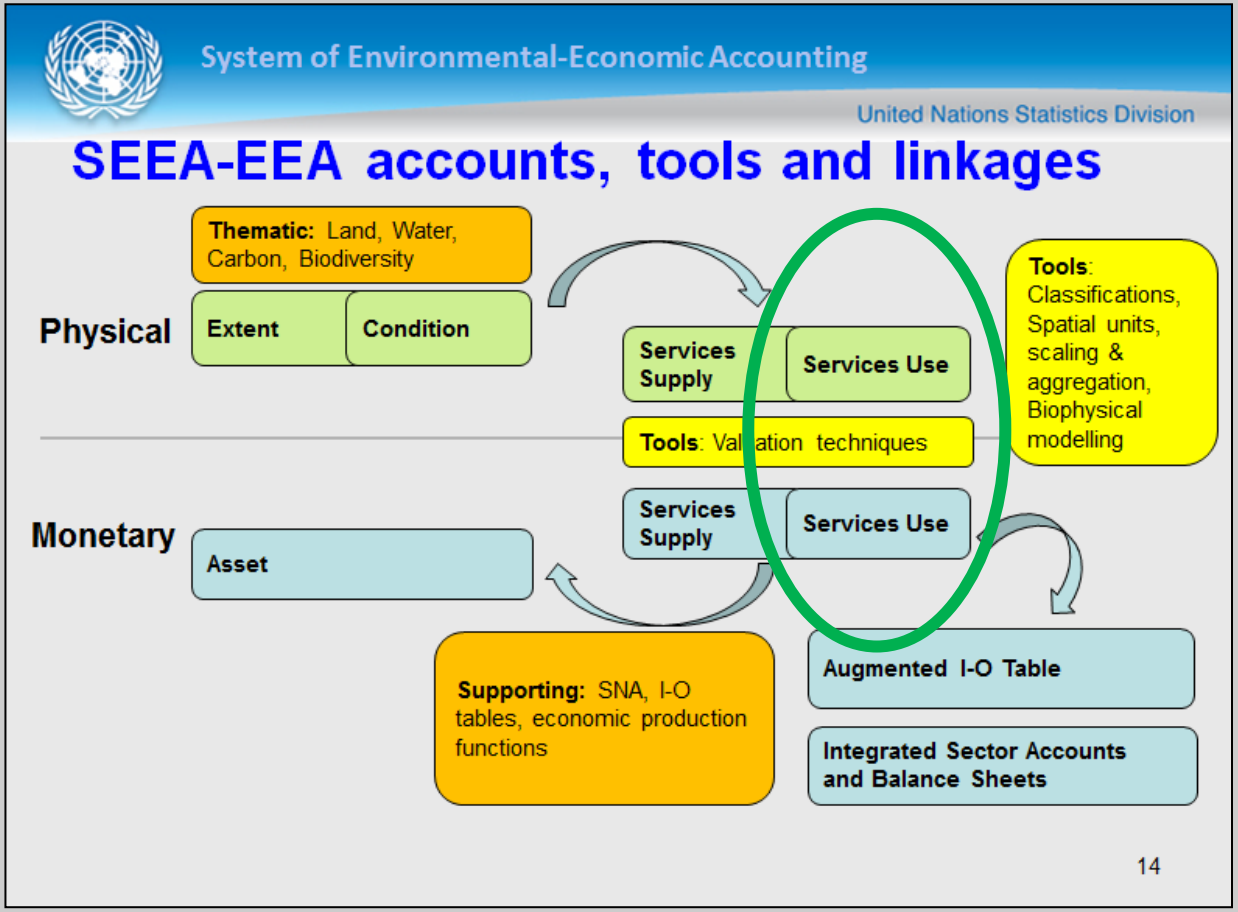
- **What does a Services Supply Account look like?**
  - Spatially-detailed physical measures of "final" services according to common **Classification**:
    - Provisioning
    - Regulating
    - Cultural
  - Physical measures (crops, flood control, clean drinking water, carbon sequestration, recreation, …)
  - **Valuation** where appropriate and available

    → **Monetary Services Supply**

Level 0: Account 6: Services Supply

- **What do you need to create a Services Supply Account?**
  - **Ecosystem Extent, Ecosystem Condition**
  - Common spatial infrastructure (**Spatial Units**)
  - Common **Classification** of services
  - **Data**:
    - Field studies
    - Transfer from other locations (**benefits transfer, valuation**)
    - Economic production (agriculture, forestry, fisheries, water)
    - **Biophysical modelling**
  - **Expertise**: ecologists, geographers (GIS), economists, policy analysts, statisticians

Account 7: Services Use



Level 0: Account 7: Services Use

- **What?**
  - Physical and monetary flows from ecosystems to **beneficiaries**
- **Why?**
  - Social, economic and environmental policies:
    - Who benefits from ecosystem services?
    - Who is dependent on ecosystem services?
  - Link to consumption accounts in SNA (**Augmented I-O…**)
  - Link to other SEEA-EEA accounts (**Services Supply**)
  - Indicators:
    - Dependence on ecosystem services → where and whom
    - Public goods from private ecosystems

Level 0: Account 7: Services Use

- **What does a Services Use Account look like?**

Tables

Services Supply Account

Type of service	Ecosystem type			
	Urban and associated	Forest tree cover	Agricultural land	Open wetlands
Provisioning		e.g., tonnes of timber	e.g., tonnes of wheat	
Regulating	e.g., tonnes of CO_2 stored / released	e.g., tonnes of CO_2 stored / released	e.g., tonnes of CO_2 stored / released	e.g., tonnes of P absorbed
Cultural	e.g., hectares of parkland	e.g., number of visitors / hikers		e.g., hectares of duck habitat

Service Type	Ecosystem Type	Use			
		Enterprises	Households	Government	Rest of the world
Provisioning	Urban and associated				
	Forest tree cover				
	Agricultural land				
	Open wetlands				
Regulating	Urban and associated				
	Forest tree cover				
	Agricultural land				
	Open wetlands				
Cultural	Urban and associated				
	Forest tree cover				
	Agricultural land				
	Open wetlands				

Allocation

Valuation

Monetary Services Use

Level 0: Account 7: Services Use

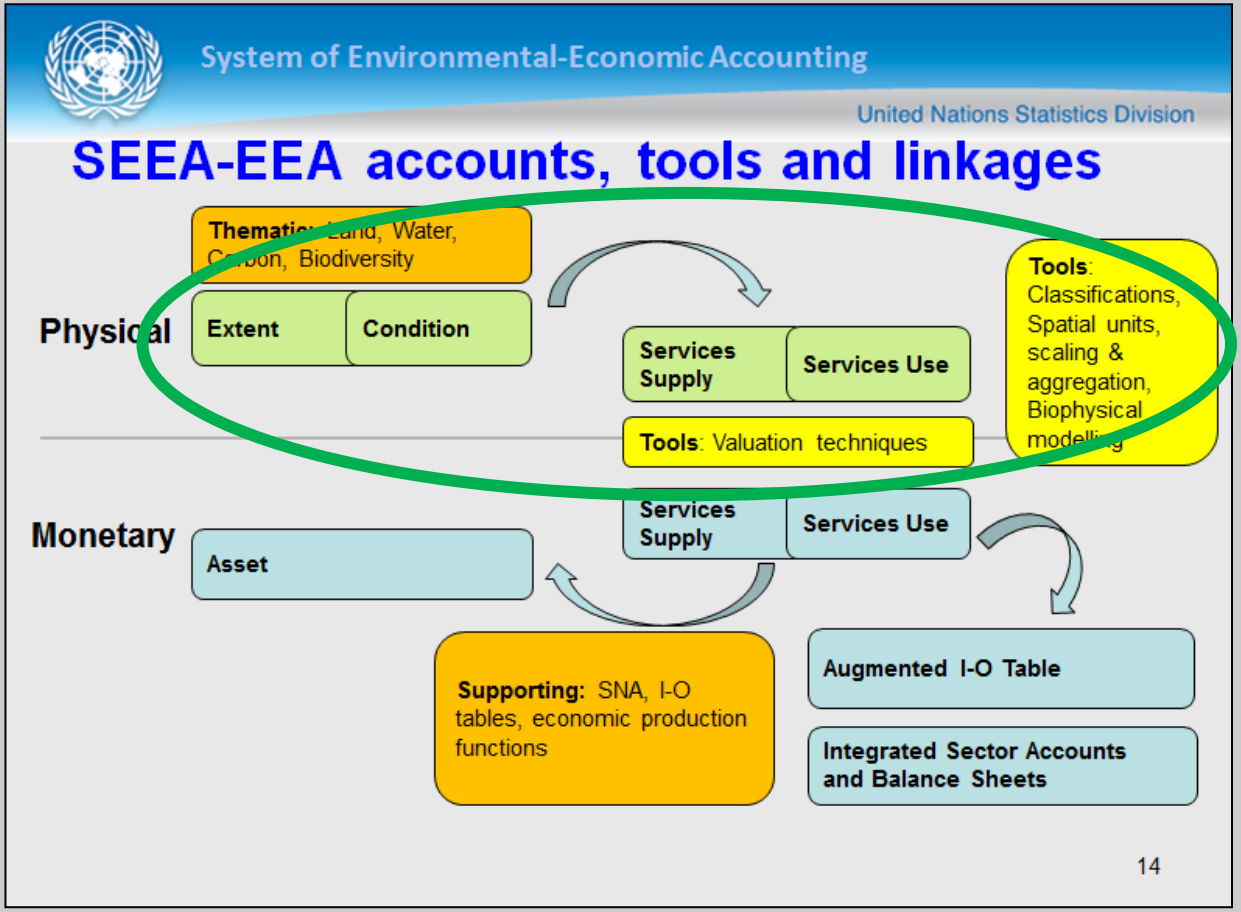
- **What does a Services Use Account look like?**
  - Aggregate tables of use of ecosystem services by:
    - Beneficiary and
    - Ecosystem type
  - Physical measures
  - Valuation where appropriate and available

    → **Monetary Services Use**

Level 0: Account 7: Services Use

- **What do you need to compile a Services Use Account?**
  - **Services Supply Account**
  - **Data**:
    - Beneficiaries of ecosystem services by:
      - service
      - type of beneficiary and
      - type of asset
  - **Expertise**: Ecosystem accounting

Account 8: Capacity



Level 0: Account 8: Capacity

- **What?**
  - **Expected** flows of services
  - Modeled using **Ecosystem Condition Account**
  - Current and future capacity to supply services
- **Why?**
  - Policies related to changing land use, land use intensity, environmental quality, population distribution
  - Ecosystem assessments: Trade-off scenarios of services for different future conditions
  - Estimate **Services Supply** if little data available
  - Calculate **Ecosystem Asset Account**
    - "Value" is Net Present Value of future flows of services
- **Indicators:**
  - Services in physical and monetary terms

Level 0: Account 8: Capacity

- **What do Capacity Accounts look like?**

Condition Account (Current)

Ecosystem type	Ecosystem extent	Ecosystem condition					
	Area	Vegetation	Biodiversity	Soil	Water	Carbon	Index
	hectares						
Urban and associated							
Rainfed herbaceous cropland							
Forest tree cover							
Inland water bodies							
Open wetlands							

Biophysical Modelling

Capacity (Current)

	Ecosystem type			
Type of service	Urban and associated	Forest tree cover	Agricultural land	Open wetlands
Provisioning		e.g., tonnes of timber	e.g., tonnes of wheat	
Regulating	e.g., tonnes of CO_2 stored / released	e.g., tonnes of CO_2 stored / released	e.g., tonnes of CO_2 stored / released	e.g., tonnes of P absorbed
Cultural	e.g., hectares of parkland	e.g., number of visitors / hikers		e.g., hectares of duck habitat

Assumptions about future

Condition Account (Future)

Ecosystem type	Ecosystem extent	Ecosystem condition					
	Area	Vegetation	Biodiversity	Soil	Water	Carbon	Index
	hectares						
Urban and associated							
Rainfed herbaceous cropland							
Forest tree cover							
Inland water bodies							
Open wetlands							

Biophysical Modelling

Capacity (Future)

	Ecosystem type			
Type of service	Urban and associated	Forest tree cover	Agricultural land	Open wetlands
Provisioning		e.g., tonnes of timber	e.g., tonnes of wheat	
Regulating	e.g., tonnes of CO_2 stored / released	e.g., tonnes of CO_2 stored / released	e.g., tonnes of CO_2 stored / released	e.g., tonnes of P absorbed
Cultural	e.g., hectares of parkland	e.g., number of visitors / hikers		e.g., hectares of duck habitat

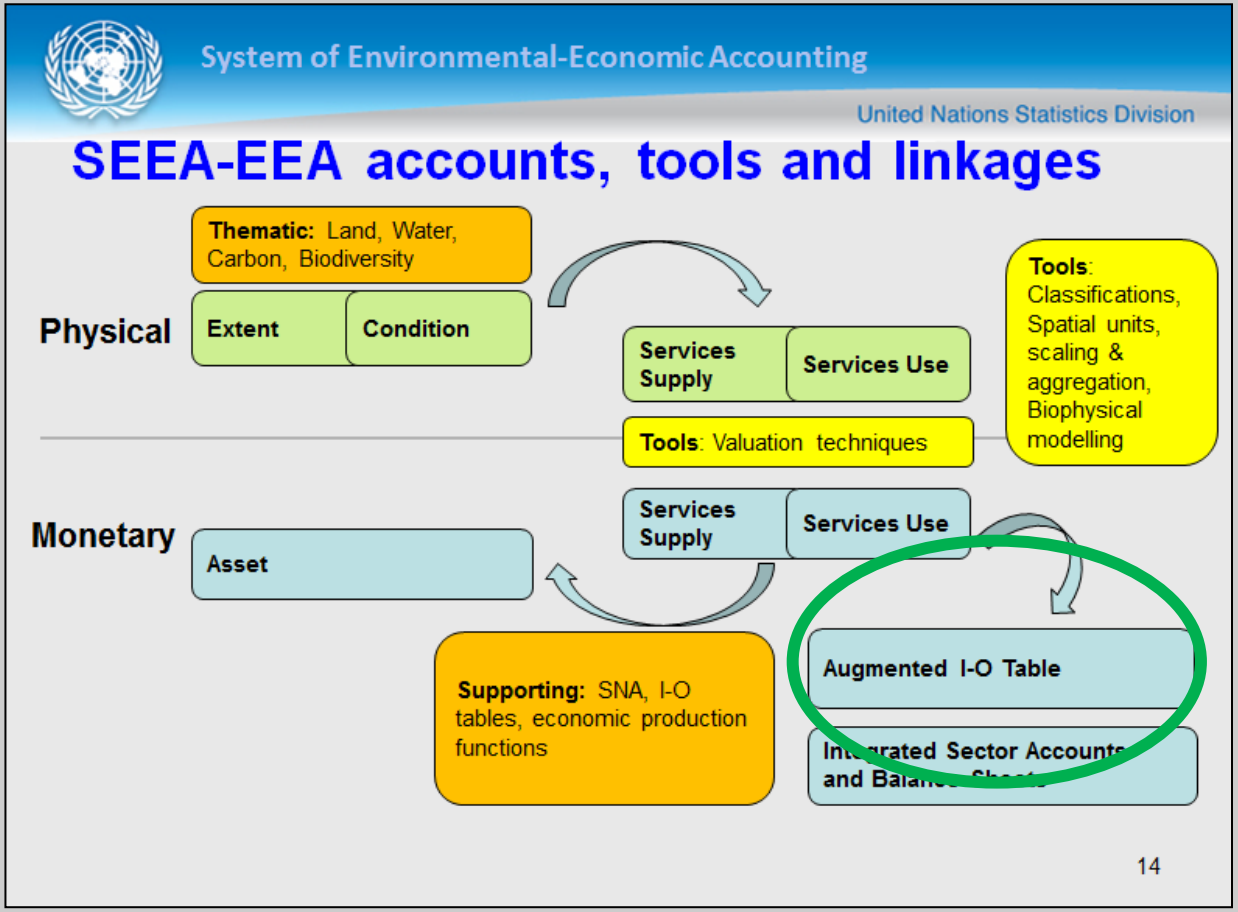
Level 0: Account 8: Capacity

- **What do Capacity Accounts look like?**
  - Spatially-detailed: by ecosystem and service type
  - Looks the same as the **Services Supply Account**
    - **But:** Services are modelled
  - Biophysical models estimate Capacity from Condition
    - Capacity Accounts record “hypothetical” flow of services
    - e.g., water purification potential of wetlands if there is no pollution or beneficiaries
  - Assumptions about the future are used to generate a future Conditions Account
    - Biophysical models estimate Future Capacity Account

Level 0: Account 8: Capacity

- **What do you need to compile a Capacity Account?**
  - **Extent Account** and **Condition Account**
  - **Ecosystem services classification**
  - Scenarios: assumptions about the future
  - **Data**:
    - Ecological production functions
    - Models may be generic or calibrated to local conditions
  - **Expertise**:
    - Ecologists (modelling & production functions)
    - Spatial analysts (many models are linked to GIS packages)
    - Ecosystem accounting (to ensure coherence)
    - Stakeholders (to agree on future scenarios)

Account 9: Augmented I-O



Level 0: Account 9: Augmented I-O

- **What?**
  - Addition to standard Input-Output tables to take into account ecosystems (producers) and ecosystem services (commodities)
- **Why?**
  - Show contribution of ecosystems and services to the economy (direct and indirect)
  - Support decisions about the economic impacts of ecosystem change
  - Link to SNA
  - Use I-O methods to balance production and consumption

Level 0: Account 9: Augmented I-O

- **What do Augmented I-O Accounts look like?**

Services Supply

Type of service	Ecosystem type			
	Urban and associated	Forest tree cover	Agricultural land	Open wetlands
Provisioning		e.g., tonnes of timber	e.g., tonnes of wheat	
Regulating	e.g., tonnes of CO_2 stored / released	e.g., tonnes of CO_2 stored / released	e.g., tonnes of CO_2 stored / released	e.g., tonnes of P absorbed
Cultural	e.g., hectares of parkland	e.g., number of visitors / hikers		e.g., hectares of duck habitat

Augmented I-O

Commodities		Producers					
		SNA industry Sectors				Ecosystems	
		1	2	3	4	1	2
SNA Commodities	1	Standard I-O Table					
	2						
	3						
	4						
Ecosystem Services	Provisioning						
	Regulating						
	Cultural						

Services Use

Service Type	Ecosystem Type	Use			
		Enterprises	Households	Government	Rest of the world
Provisioning	Urban and associated				
	Forest tree cover				
	Agricultural land				
	Open wetlands				
Regulating	Urban and associated				
	Forest tree cover				
	Agricultural land				
	Open wetlands				
Cultural	Urban and associated				
	Forest tree cover				
	Agricultural land				
	Open wetlands				

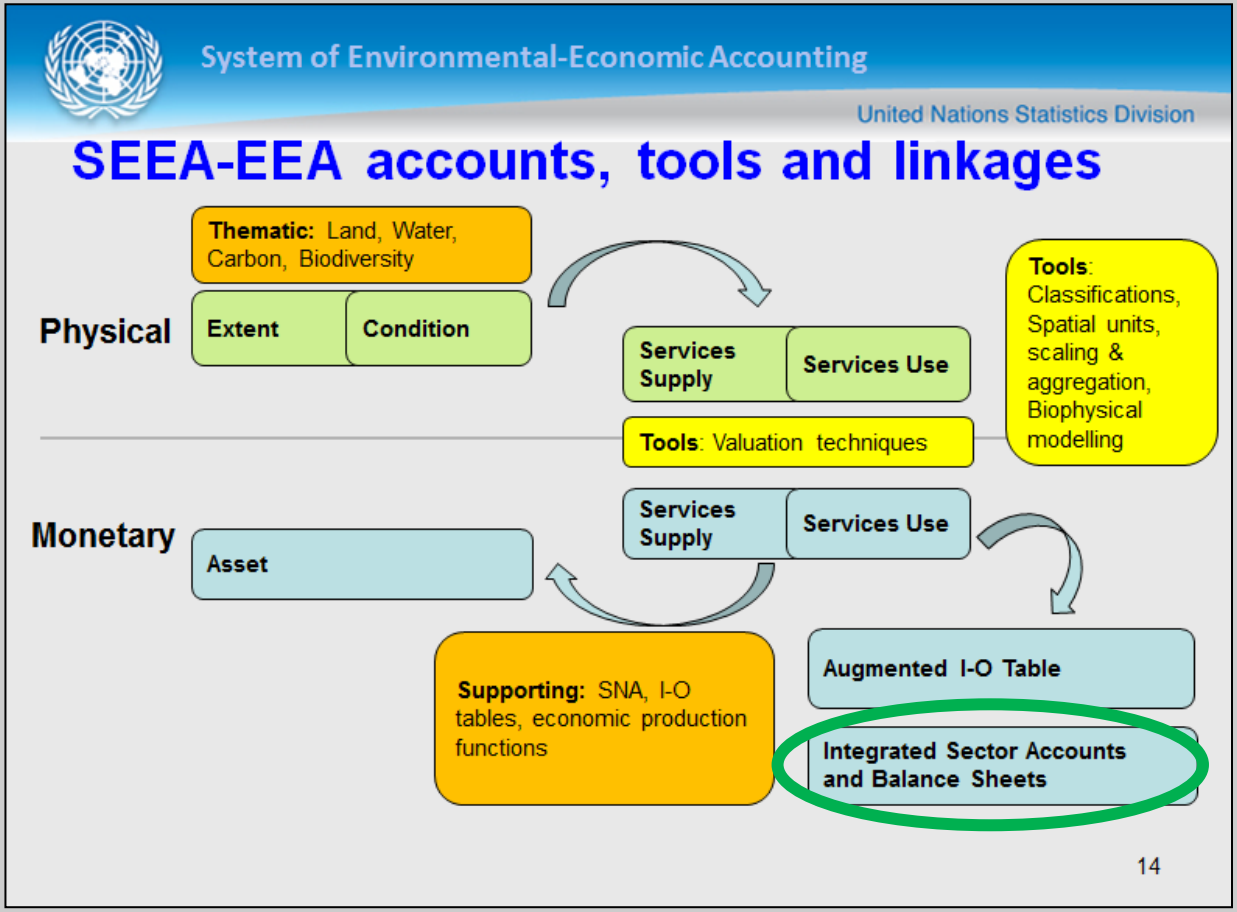
Level 0: Account 9: Augmented I-O

- **What do you Augmented I-O Accounts look like?**
  - National level I-O tables (provincial or state if available)
  - Rows added for commodities (ecosystem services)
  - Columns added for producers (ecosystems)
  - Physical or monetary
    - Need monetary to balance

Level 0: Account 9: Augmented I-O

- **What do you need to compile Augmented I-O Accounts?**
  - Services Supply Account (physical and monetary)
  - Services Use Accounts (physical and monetary)
  - **Data:**
    - Economic production functions including ecosystem services
      - e.g., crop = f(ecosystem services, capital, labour…)
  - **Expertise:**
    - Input-Output experts (set up and operation)
    - Productivity experts (production functions)
    - Ecological economists (production functions)

Account 10: Integrated Sector Accounts and Balance Sheet



Level 0: Account 10: Integrated Sector Accounts and Balance Sheet

- **What?**
  - Economic sector level summary accounts
  - Standard aggregates adjusted for degradation
- **Why?**
  - Augment the economic accounts of the SNA by integrating into the sequence of accounts
  - **Integrated Sector Accounts** produce aggregate measures of economic activity, such as national income and saving, which are adjusted for ecosystem degradation.
  - **Balance Sheets** compare the values of ecosystem assets with values of produced assets, financial assets (and liabilities) and other economic assets.

Level 0: Account 10: Integrated Sector Accounts and Balance Sheet

- **What do Integrated Sector Accounts and Balance Sheet look like?**

Asset

Services Supply

Services Use

SNA

Accounting entry	Institutional Sectors				
	Corporations	General government	Households	NPISH	Total Economy
Production account					
Depletion-adjusted Net Value Added					
Generation of income account					
Depletion-adjusted Net Operating Surplus					
Allocation of primary income account					
Depletion-adjusted balance of primary income					
Distribution of secondary income account					
Depletion-adjusted Net Disposable Income					
Use of disposable income account					
Depletion adjusted Net Saving					
Capital account					
Net lending/borrowing					

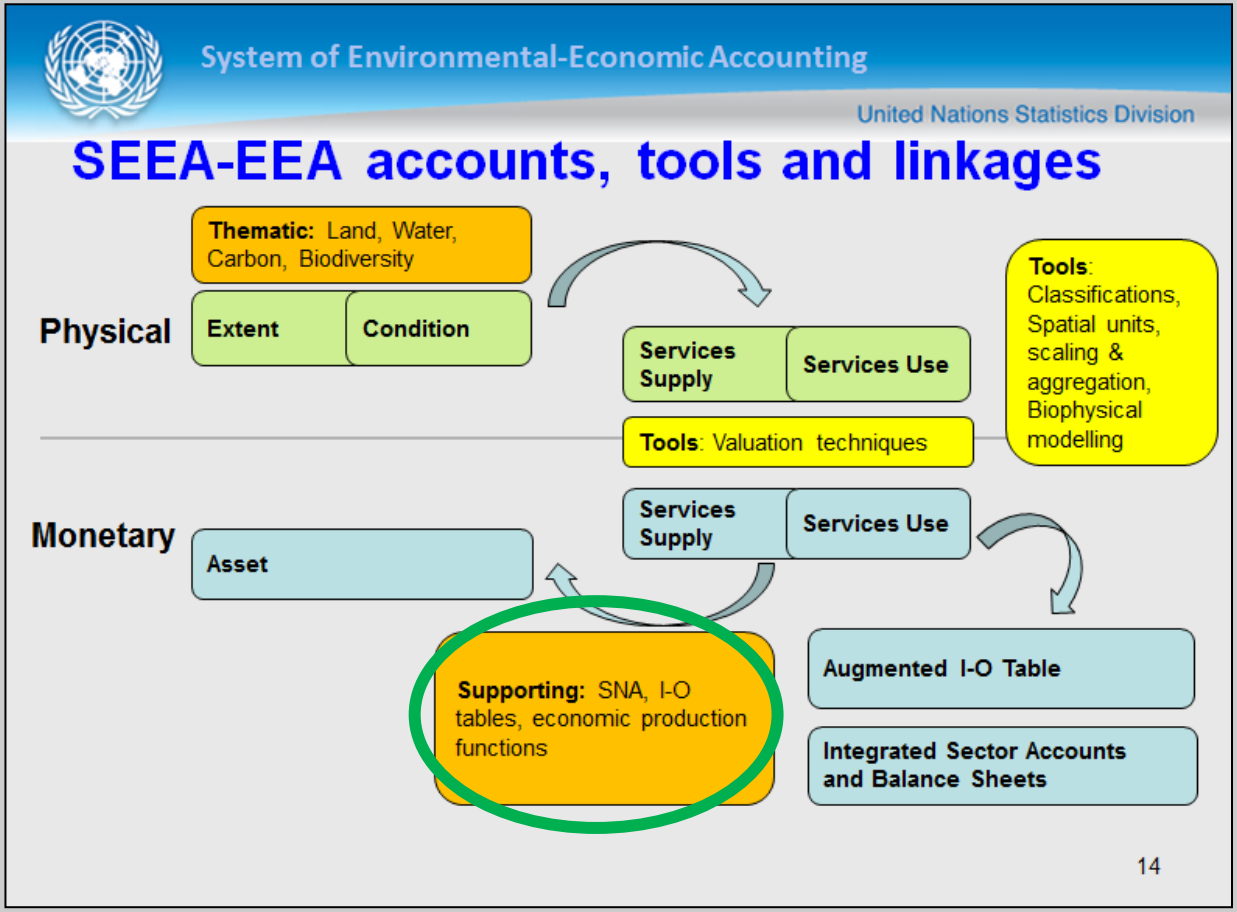
Level 0: Account 10: Integrated Sector Accounts and Balance Sheet

- **What do Integrated Sector Accounts and Balance Sheet look like?**
  - For example, the Production Account takes
    - Total Output
      Less: Intermediate consumption
      = *Gross Value Added*
      Less: Consumption of Fixed Capital
      = *Net Value Added*
      Less Depletion/Degradation of natural resources
      = *Depletion-adjusted Net Value Added*
  - Similar calculations result in other important indicators:
    - *Depletion-adjusted Net Saving*

Level 0: Account 10: Integrated Sector Accounts and Balance Sheet

- **What do you need to compile Integrated Sector Accounts and Balance Sheet?**
  - Asset Account
  - Services Supply Account
  - Services Use Account
  - SNA
- **Data:**
  - Monetary value of assets, services
- **Expertise:**
  - National accounting
  - Ecosystem accounting

Supporting information: Socio-economic



Level 0: Supporting Information: Socio-economic

- **What?**
  - Socio-economic data and other drivers of change
- **Why?**
  - People, governments and businesses are drivers of change **and** beneficiaries of Ecosystem Services
  - Understand **why** a change occurred (natural or human?)
  - Support scenarios of future (**Capacity**)
  - Links to SEEA-EEA accounts (**Extent, Condition, Water, Carbon, Biodiversity, Services Supply, Services Use, Asset**)
  - **Indicators:**
    - Allocate changes in assets to local, national and global drivers
    - Allocate supply of services to beneficiaries
    - Estimate dependence of population and business on ecosystems (food security, water security, flood risks)

Level 0: Supporting Information: Socio-economic

- **What does Socio-economic Information look like?**
  - Drivers of change:
    - Maps or tables to explain changes in Extent, Conditions and Services Supply
      - e.g., changes in land-use
      - e.g., trends in rainfall
  - Socio-economic data:
    - Maps or tables to explain business and population drivers
      - e.g., changes in commodity prices
      - e.g., trends in population growth
    - Maps or tables to calculate beneficiaries
      - e.g., population distribution

Level 0: Supporting Information: Socio-economic

- **What do you need to compile Socio-economic information?**
  - Common spatial infrastructure (**Spatial Units**)
  - **Drivers of change data**:
    - Local, global climate
    - Global, national, local economic conditions (GDP, employment, growth rates)
    - Local activities (agriculture intensity, forestry intensity, recreation intensity)
    - Local development plans (land use, urban expansion)
  - **Expertise**: Economists, climate specialists, sociologists, regional planners

Level 0: Supporting Information: Socio-economic

- **What do you need to compile Socio-economic information?**
  - **Socio-economic data:**
    - Local population distribution (Census, surveys, case studies):
      - Income
      - Industry of employment
      - Dependence on nature (**Case studies**)
    - Business types by location (surveys, Business Register)
      - Environmental protection expenditures
      - Dependence on nature (biomass, energy, water, pollution regulation…)
  - **Expertise:** Economists, sociologists, statisticians, geographers (GIS, integration)

End of Accounts…

Questions?
Discussion

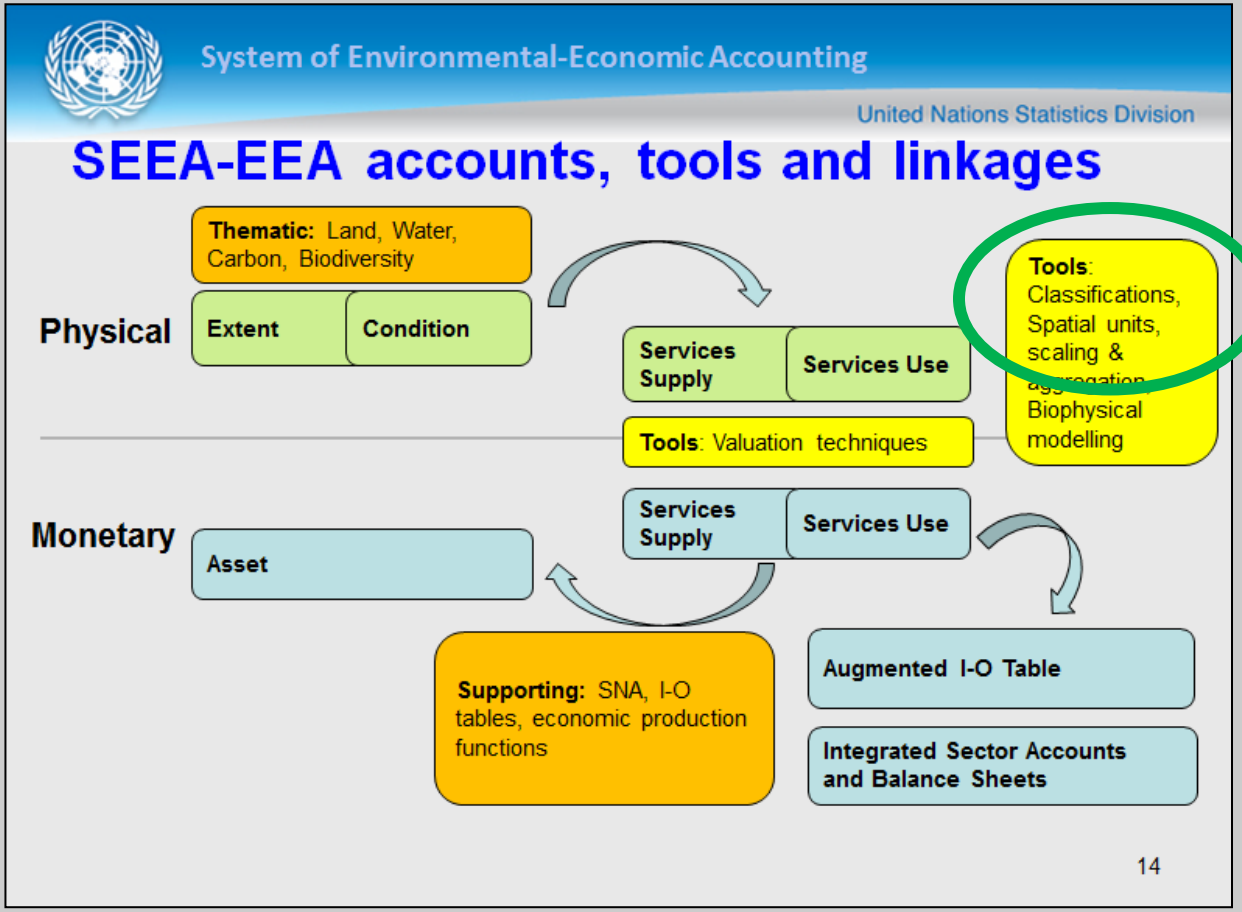
- Prepare for group exercise…think about:
  - What are your priority accounts?
  - What are the opportunities to produce them?
    - Stakeholders?
    - Institutional mechanisms?
    - Current activities?
  - What are the constraints?
    - Data?
    - Capacity?

- Next up: **Tools**

Level 0: Tools

- Classifications
- Spatial units, scaling & aggregati
- 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



Level 0: Tools 1: Classifications

- **What?**
  - From SEEA-CF:
    - Land Cover, Land Use
    - Economic units, industry sectors
  - New:
    - Final ecosystem services
- **Why?**
  - Accounting needs **C**onsistent and **C**oherent and **C**omprehensive: **C**lassifications
    - **C**onsistent: use same classification for same concept
    - **C**oherent: with other classifications
    - **C**omprehensive: "**C**lassifications **C**ertify **C**omplete **C**overage"

Level 0: Tools 1: Classifications

- **Land Cover**
- From SEEA-CF (p.276)
- Uses FAO LCCS3 (Food and Agriculture Organization – Land Cover Classification System v3) definitions
- High-level aggregate:
  - May adapt to local situations
  - Used as basis for "ecosystem type"

01 Artificial surfaces (including urban and associated areas)
02 Herbaceous crops
03 Woody crops
04 Multiple or layered crops
05 Grassland
06 Tree covered areas
07 Mangroves
08 Shrub covered areas
09 Shrubs and/or herbaceous vegetation, aquatic or regularly flooded
10 Sparsely natural vegetated areas
11 Terrestrial barren land
12 Permanent snow and glaciers
13 Inland water bodies
14 Coastal water bodies and inter-tidal areas

Level 0: Tools 1: Classifications

- **Land Use**
- From SEEA-CF (p. 266)
- Detailed (4-digit level)

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

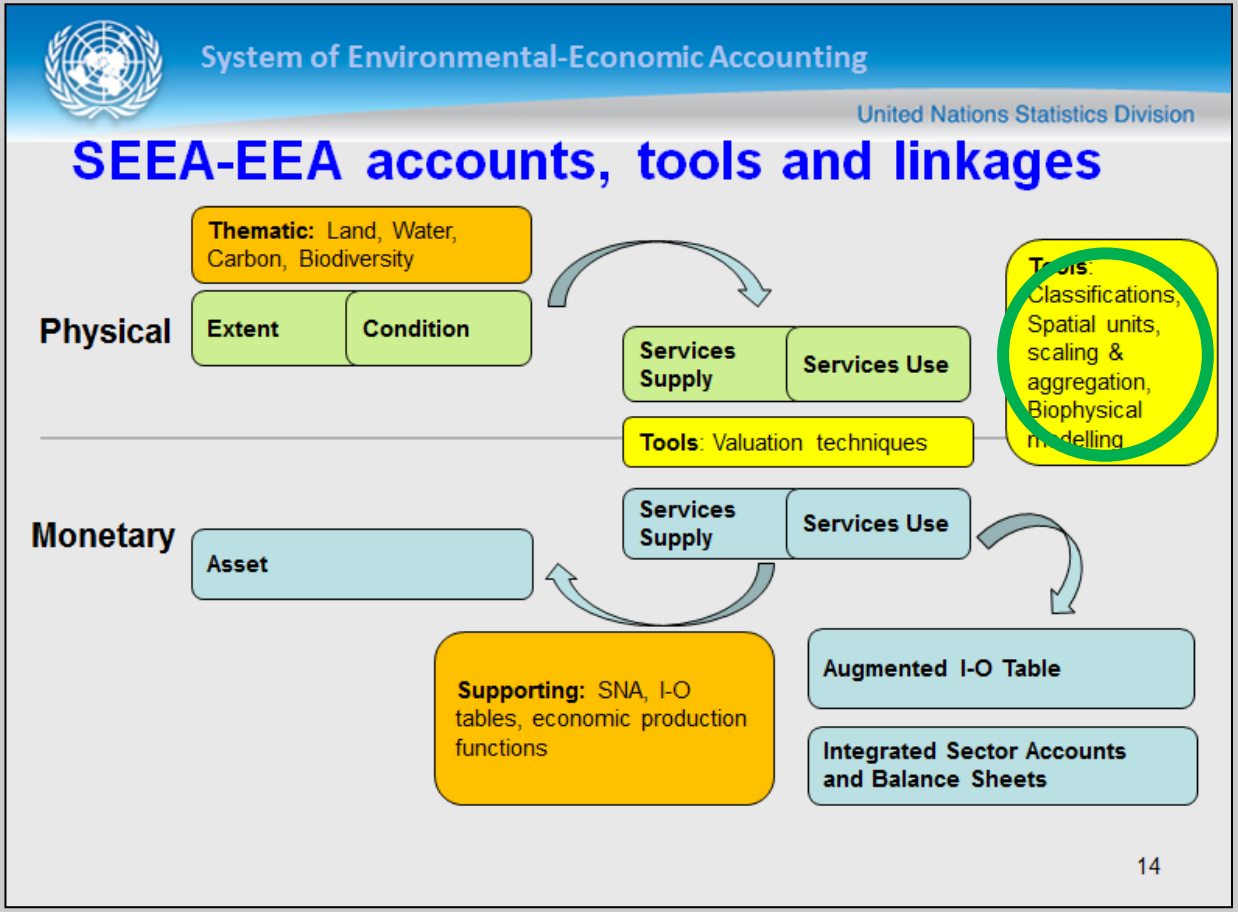
- **Services**
- Based on **Common International Classification of Ecosystem Services** (CICES)
- Not mutually exclusive
- A list of "final" services
- More detail (4-digit)
- Does not include "supporting services" (= ecosystem functions)

Section	Division	Group
01. Provisioning	01.01 Nutrition	01.01.01 Biomass
		01.01.02 Water
	01.02 Materials	01.02.01 Biomass
		01.02.02 Water
	01.03 Energy	01.03.01 Biomass-based energy sources
		01.03.02 Mechanical energy
02. Regulation & Maintenance	02.01 Mediation of waste, toxics and other nuisances	02.01.01 Mediation by biota
		02.01.02 Mediation by ecosystems
	02.02 Mediation of flows	02.02.01 Mass flows
		02.02.02 Liquid flows
		02.02.03 Gaseous / air flows
	02.03 Maintenance of physical, chemical, biological conditions	02.03.01 Lifecycle maintenance, habitat and gene pool protection
		02.03.02 Pest and disease control
		02.03.03 Soil formation and composition
		02.03.04 Water conditions
		02.03.05 Atmospheric composition and climate regulation
03. Cultural	03.01 Physical and intellectual interactions with biota, ecosystems, and land-/seascapes [environmental settings]	03.01.01 Physical and experiential interactions
		03.01.02 Intellectual and representative interactions
	03.02 Spiritual, symbolic and other interactions with biota, ecosystems, and land-/seascapes [environmental settings]	03.02.01 Spiritual and/or emblematic
		03.02.02 Other cultural outputs

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



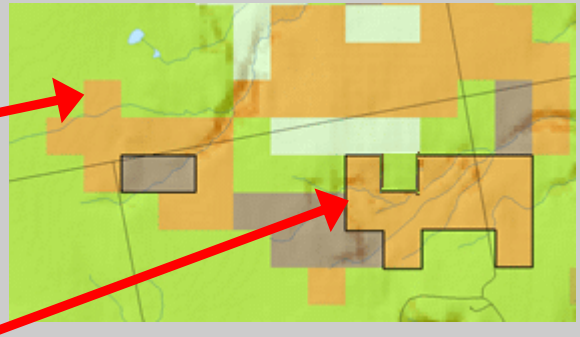
Level 0: Tools 2: Spatial units

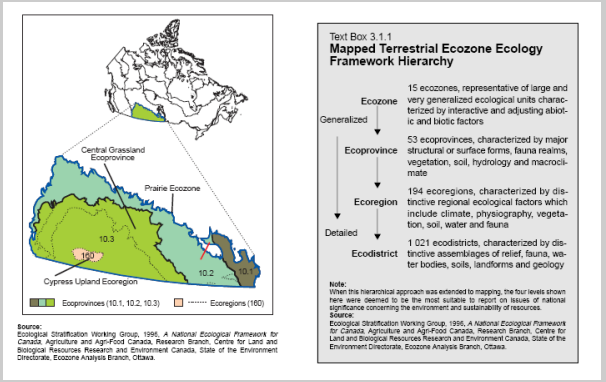
- **What?**
  - A common definition of Spatial Units for all accounts
  - Based on surface characteristics (terrestrial, freshwater, coastal and marine)
- **Why?**
  - Accounting needs **statistical units** about which information is compiled, derived, reported and compared
    - e.g., business statistics 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…**)

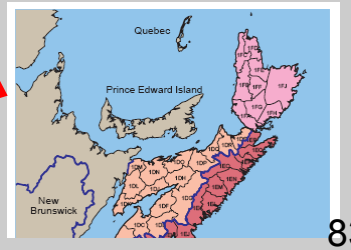
Level 0: Tools 2: Spatial units

Recommended three levels: hierarchical and mutually exclusive:

1. Basic Spatial Unit **(BSU)**
   - Pixel or grid cell
2. Ecosystem Unit **(EU)**
   - Homogenous according to criteria (cover, slope, drainage area, elevation…)
   - Consolidate for tables by EU type
3. Ecosystem Reporting Area **(ERA)**
   - For reporting (sub-drainage area, administrative area…)







→ **Establishes Ecosystem Extent Account**

Source: Statistics Canada, 2013

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

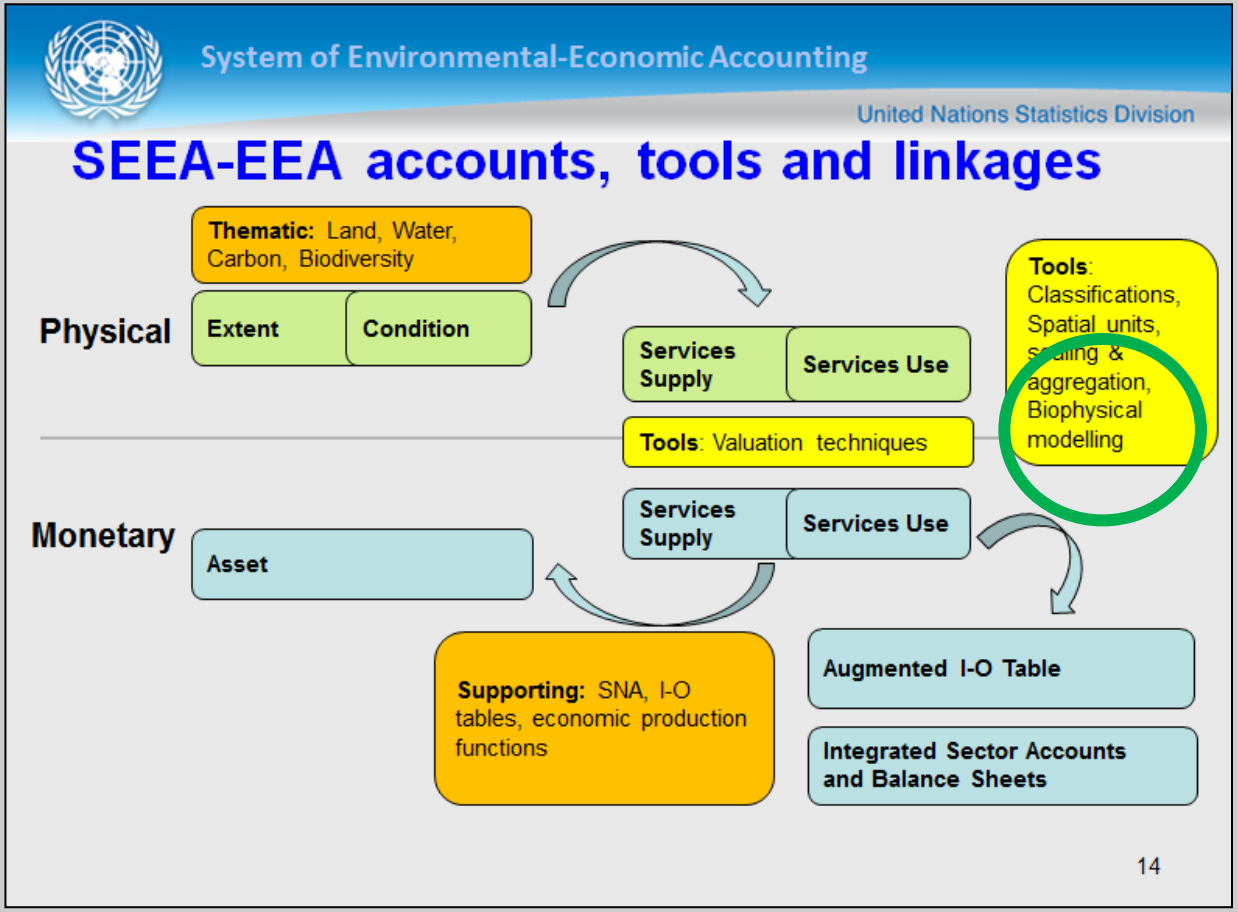
- **What?**
  - Combining many measures into simpler ones
  - Dissimilar measures may be aggregated using:
    - Indices (e.g., water quality index)
    - Conversion to common units (e.g., CO_2 equivalents)
- **Why?**
  - Accounting requires **aggregates** (of dollars, business types, sub-populations, 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



Level 0: Tools 3: Biophysical modelling

- **What?**
  - Four main approaches:

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

- **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

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.

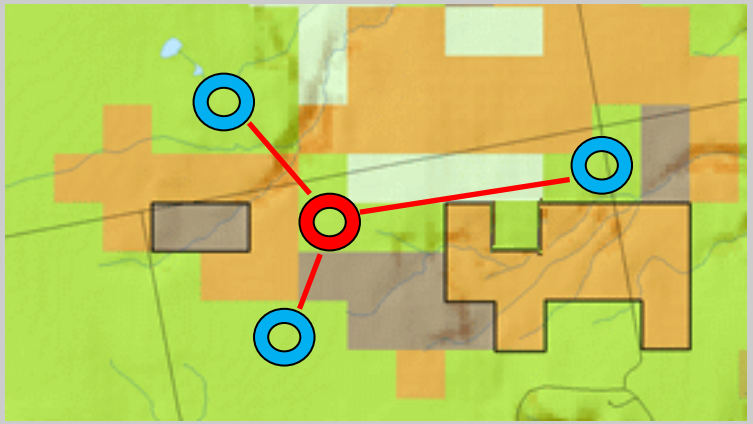
- Example: **Function Transfer**
- *Value = f(land cover, population, roads, climate)*
- Error rate = 40-50%

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 = ?



Unknown

Known

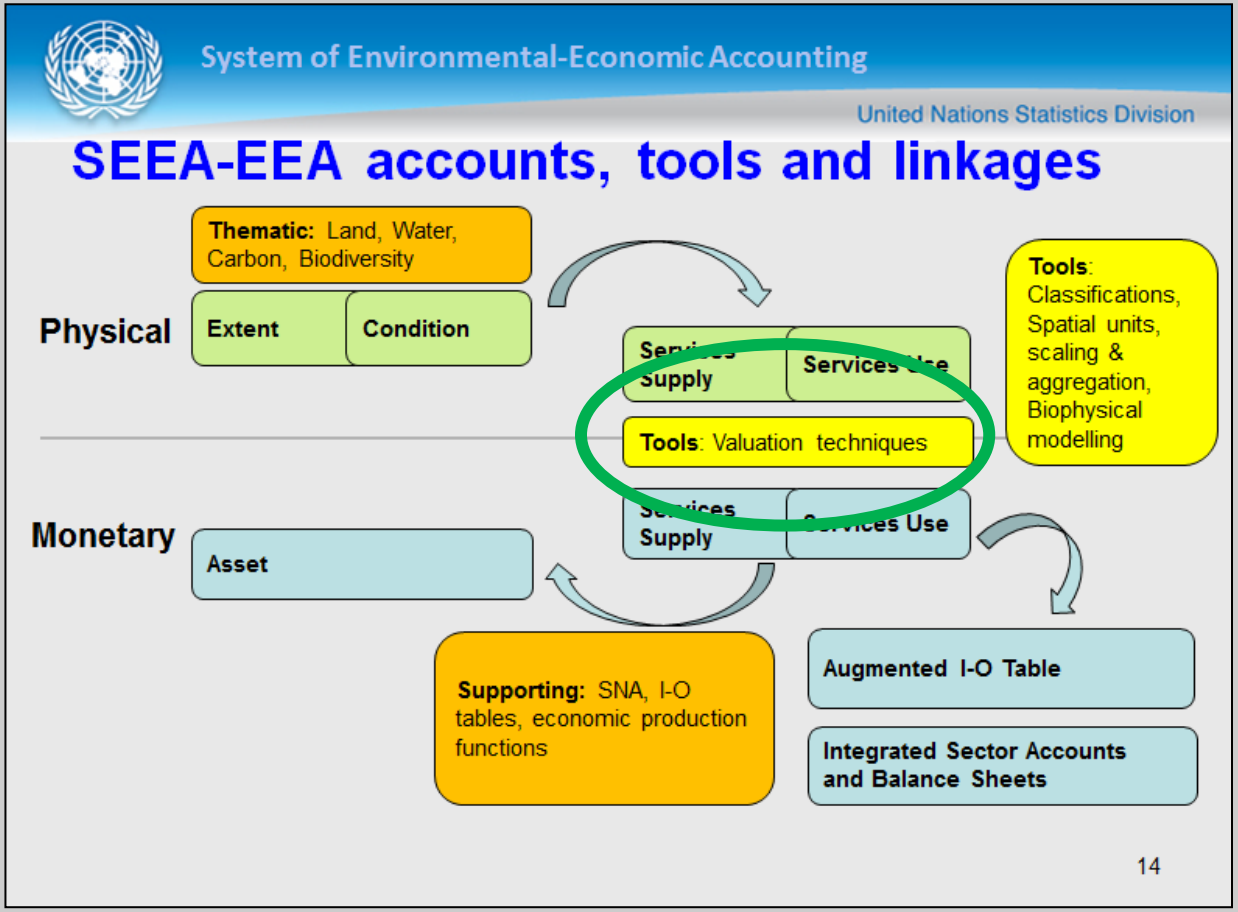
Level 0: Tools 3: Biophysical modelling

- **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%

Tools 4: Valuation techniques



Level 0: Tools 4: Valuation

- **What?**
  - Attributing economic or social value to assets & services
  - Ecosystem services valuation produces:
    - Average values (per hectare, under specific conditions)
    - **Or** Marginal values (change in value of converting one hectare)
  - Asset valuation:
    - Scenarios of future **Conditions** and demand → net present value of **Ecosystem Asset**
- **Why?**
  - Integrate with SNA
    - **Augmented I-O, Integrated Sector Accounts and Balance Sheet**
  - Assessing trade-offs: Convert or protect?
  - Monetary valuation is embedded in many:
    - National plans: cost/benefit, payment & compensation schemes
    - Research approaches: contingent valuation, choice modelling

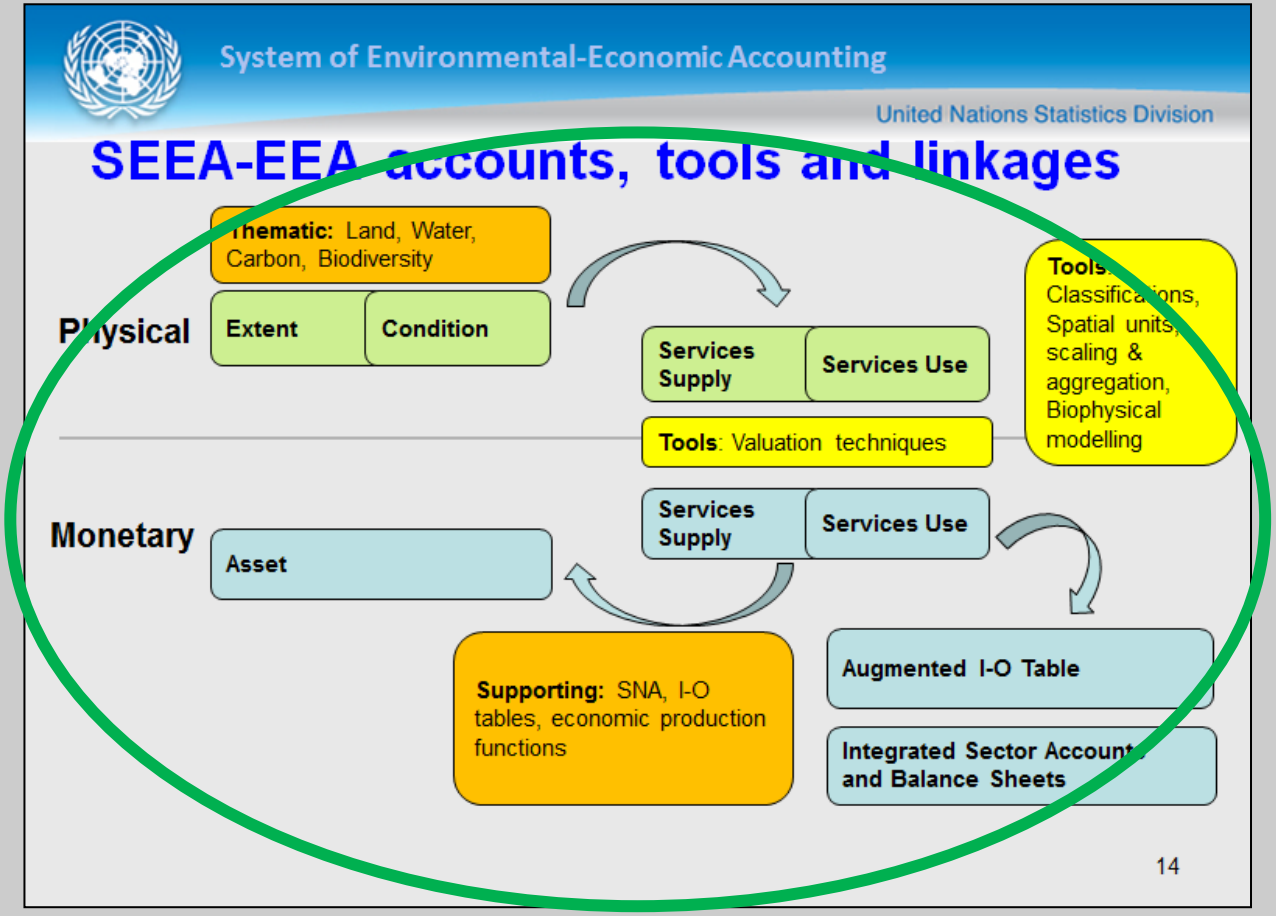
Level 0: Tools 4: Valuation

- **Approaches (non-market)**:
  - **Revealed preferences:**
    - **Production function:** (resource rent)
      - value = f(ecosystem, produced capital, labour)
    - **Replacement cost:** produce service with another ecosystem/asset
    - **Hedonic pricing:** real-estate prices, wages with respect to distance
    - **Averting behaviour:** expenditures to avoid degradation
    - **Travel cost:** expenditures to enjoy a service (e.g., recreation)
  - **Stated preference:**
    - Contingent valuation, choice modelling: willingness to pay
  - **Simulated exchange values**: model supply/demand
  - **Payments for ecosystem services (PES)**:
    - Carbon, biodiversity markets
  - **Payments made to improve condition**: Rehabilitation costs

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**)
  - Highly dependent on decision context
    - Project assessment: trade-offs
    - Long-term sustainable use of ecosystems: high-level indicators
    - Payments and compensation: needs to have precise values

Tools 5: Other tools



Level 0: Tools 5: Other tool

- **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…)

Other related training materials

- Secretariat for the Convention on Biological Diversity (SCBD)
  - Quick Start Package (QSP) (Weber, 2014)
    - Available online at www.ecosystemaccounting.net
    - Includes free GIS software and tutorials
  - National Biodiversity Strategies and Action Plans
    - Training modules at www.cbd.int/nbsap/training/
- World Bank WAVES
- Statistics Canada:
  - Measuring Ecosystem Goods and Services Teacher's Kit

Evaluation of the training module

- Please complete the online evaluation form for this module: http://tinyurl.com/pbopmy2
- For this module
  - What did you learn that you could apply in your work?
  - Was the presentation clear and informative?
  - Was it too simple? Too complex?
  - Was there anything you did not understand?
  - What additions or deletions would you suggest (recognizing that the unit is intended for a general audience)?
  - Do you have any suggestions as to how the SEEA-EEA may be improved (concepts, principles) in this area?

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

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- Contact: seea@un.org

United Nations UNEP Convention on Biological Diversity NORWEGIAN MINISTRY OF FOREIGN AFFAIRS