

System of
Environmental
Economic
Accounting



Overview of ecosystem services accounts and small introduction to valuation

Sokol Vako

United Nations Statistical Institute for Asia and the Pacific

June 2023 –

Based on presentation from Julian Chow (UNSD) and Alejandro Caparrós (Durham University)

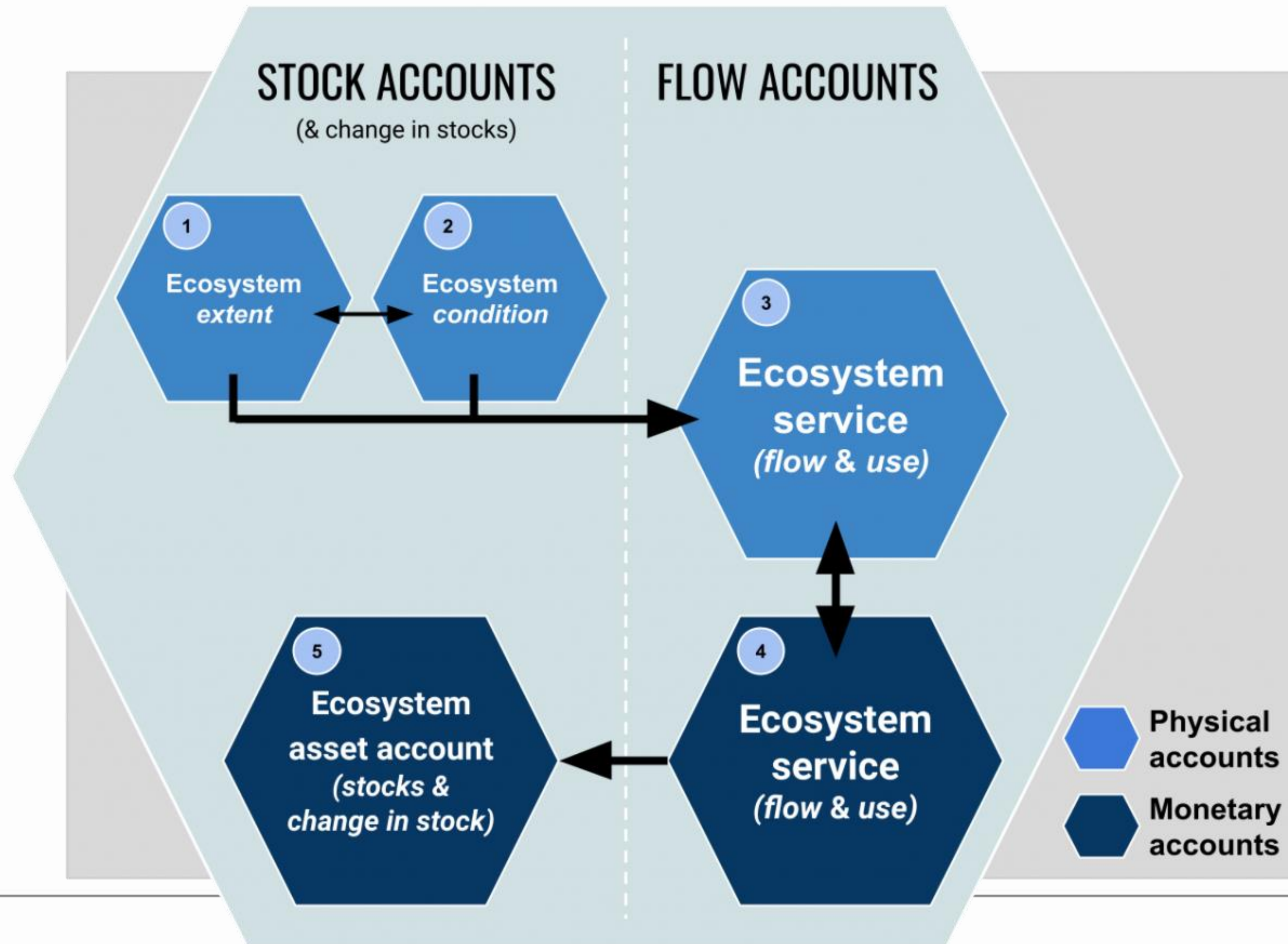


United Nations

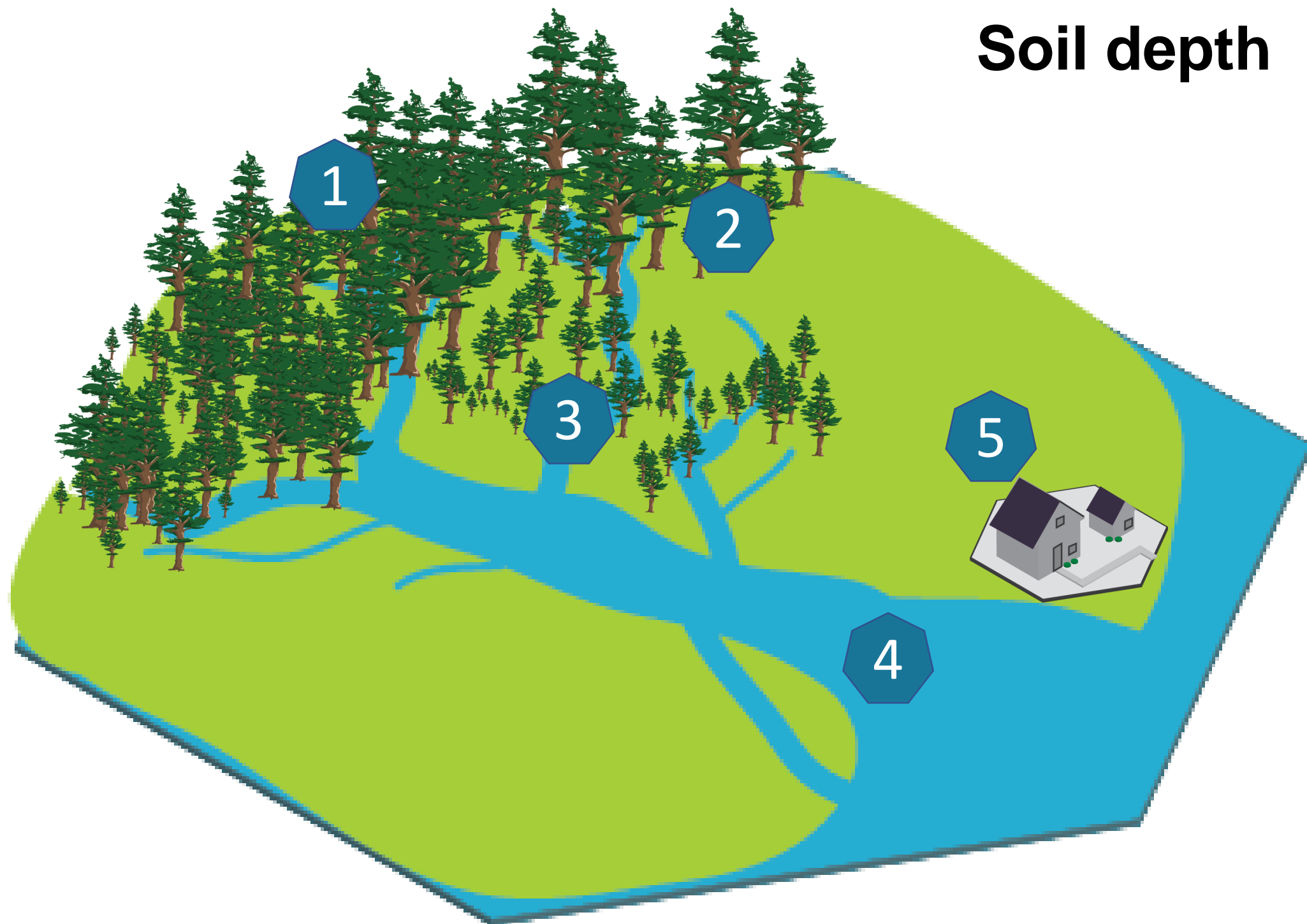
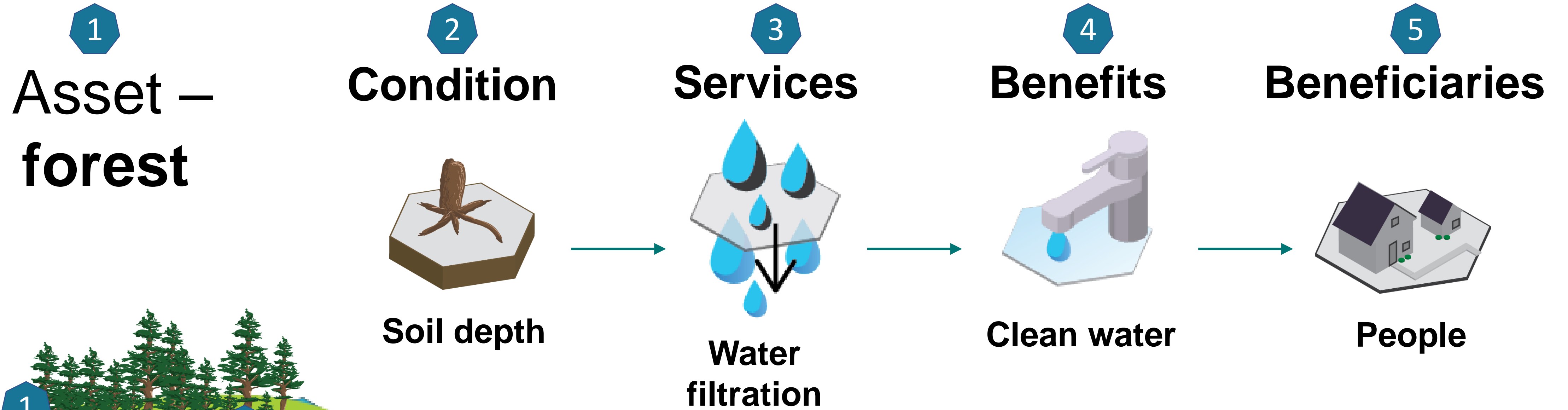
Ecosystem Accounting

- SEEA relation to SNA:
 - > SEEA CF expands asset boundary
 - > SEEA EA expands also the production boundary with ecosystem services
- Ecosystem services in SEEA
 - > contributions to benefits used by people where benefits are the goods and services that are ultimately used and enjoyed by people and society
 - > conceptualized as transactions between ecosystems assets (supply) and beneficiaries (users)
- Integration with sequence of accounts
 - > Additional output + degradation costs + extended balance sheets

SEEA EA Framework

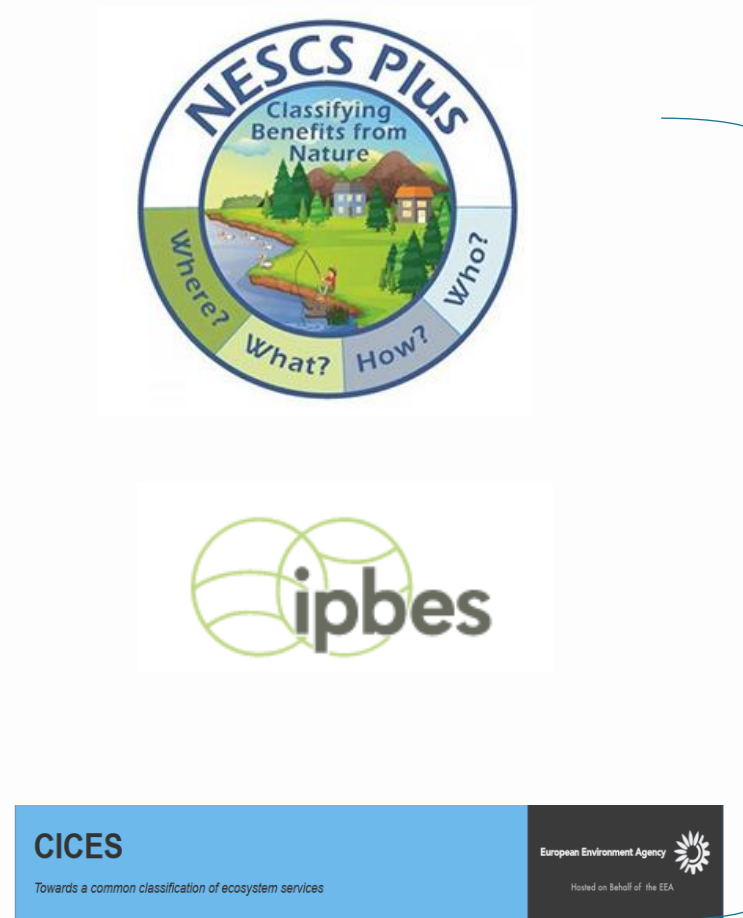


SEEA EA Framework – Illustrative Example



Ecosystem services

- SEEA EA includes a reference list of 25 Ecosystem Services



- Provisioning:
 - > Biomass
 - Grazed biomass
 - Livestock
 - Aquaculture
 - Wood
 - Wild fish + other
 - Wild animals, plants + other
 - > Genetic material
 - > Water supply
- Cultural:
 - > Recreation-related
 - > Visual amenity
 - > Education, scientific and research
 - > Spiritual, artistic and symbolic services
- Other ES
- Non-use

- Regulating and maintenance services
 - > Global climate regulation
 - > Rainfall pattern
 - > Local (micro and meso) climate regulation
 - > Air filtration
 - > Soil quality regulation
 - > Soil and sediment retention
 - > Solid waste remediation
 - > Water purification
 - > Water flow regulation
 - > Flood control
 - > Storm mitigation
 - > Noise attenuation
 - > Pollination
 - > Biological control
 - > Nursery population & habitat maintenance

Some additional concepts and term

- Benefits fall into two broad groups:
 - > SNA benefits (e.g., water used in crop production)
 - > Non-SNA benefits (e.g., flood protection)
- Final and intermediate services
- Users and beneficiaries

Ecosystem Services supply and use account

- Follow the supply and use tables (SUT) described in the SNA and the SEEA Central Framework
- Structured to record flows of final ecosystem services between economic units and ecosystems and flows of intermediate services among ecosystem services
- Entries can be made in physical and monetary terms
- A key principle of the supply and use table structure is that the supply of ecosystem services is equal to the use of those services during an accounting period

Supply Table

SUPPLY			UNIT S OF MEASURE													Forest	Lake	Cropland	Urban area	Wetland	Seagrass	Total supply resident ecosystem assets	Supply from non-resident ecosystem assets - Imports		TOTAL SUPPLY	
																							Intermediate	Final		
Selected ecosystem services																										
Provisioning services																										
	Biomass provisioning	Crop provisioning	tonnes												150					150	0	0		150		
		Wood provisioning services	m³											140						140	0	0		140		
		Wild fish and other natural aquatic biomass provisioning services	tonnes												3				6	9	0	0		9		
Regulating and maintenance services																										
	Global climate regulation services		tonnes CO ₂											150				5	20	250	425	0	0		425	
	Water purification services		tonnes N removed																7	7	0	0		7		
Cultural services																										
	Recreation-related services		# visits											1,500	5,000			2,500		800	9,800	0	0		9,800	

Supply Table

Supply table rows show the various ecosystem services. They are classified based on the reference list of ecosystem services

Supply table columns present the ecosystem assets by type and imports. The ecosystem assets are classified based on the IUCN Global Ecosystem Typology

		UNIT S OF MEASURE																	TOTAL SUPPLY			
																			Supply from non-resident ecosystem assets - Imports		Final	Intermediate
Selected ecosystem services																						
Provisioning services																						
	Biomass provisioning	Crop provisioning	tonnes											150			150	0	0	150		
		Wood provisioning services	m³										140			140	0	0	140			
		Wild fish and other natural aquatic biomass provisioning services	tonnes											3		6	9	0	0	9		
Regulating and maintenance services																						
	Global climate regulation services		tonnes CO ₂										150			5	20	250	425	0	0	425
	Water purification services		tonnes N removed														7		7	0	0	7
Cultural services																						
	Recreation-related services		# visits										1,500	5,000		2,500		800	9,800	0	0	9,800

Supply table rows show the various ecosystem services. They are classified based on the reference list of ecosystem services

Supply Table

SUPPLY		UNITS OF MEASURE											Forest	Lake	Cropland	Urban area	Wetland	Seagrass	Total supply resident ecosystem assets	Supply from non-resident ecosystem assets - Imports		TOTAL SUPPLY	
																				Intermediate	Final		
Selected ecosystem services																							
Provisioning services																							
	Biomass provisioning	Crop provisioning	tonnes												150				150	0	0	150	
		Wood provisioning services	m³										140						140	0	0	140	
		Wild fish and other natural aquatic biomass provisioning services	tonnes											3				6	9	0	0	9	
Regulating and maintenance services																							
	Global climate regulation services		tonnes CO ₂										150			5	20	250	425	0	0	425	
	Water purification services		tonnes N removed														7		7	0	0	7	
Cultural services																							
	Recreation-related services		# visits										1,500	5,000		2,500		800	9,800	0	0	9,800	

The measures recorded in the supply tables are direct measures of the services - or proxies for the services in question if the services themselves cannot readily be measured.

SUPPLY		UNIT S OF MEASURE											Forest	Lake	Cropland	Urban area	Wetland	Seagrass	Total supply resident ecosystem assets	Supply from non-resident ecosystem assets - Imports		TOTAL SUPPLY
																				Intermediate	Final	
Selected ecosystem services																						
Provisioning services																						
	Biomass provisioning	Crop provisioning	tonnes											150				150	0	0	150	
		Wood provisioning services	m³									140						140	0	0	140	
		Wild fish and other natural aquatic biomass provisioning services	tonnes										3				6	9	0	0	9	
Regulating and maintenance services																						
	Global climate regulation services		tonnes CO ₂									150			5	20	250	425	0	0	425	
	Water purification services		tonnes N removed													7		7	0	0	7	
Cultural services																						
	Recreation-related services		# visits									1,500	5,000		2,500		800	9,800	0	0	9,800	

Cropland is shown to provide 150 tonnes of **crop provisioning services** - the ecosystem's contribution to the various crops harvested during the accounting period within the accounting area.

A total of 425 tonnes of **global climate regulation services** (measured in terms of carbon dioxide absorption) are shown to be provided by forests, urban areas, wetlands and seagrass.

Wetlands are shown to provide 7 tonnes (measured in terms of nitrogen removal) of **water purification services**.

Use Table

USE			UNIT & OF MEASURE	Agriculture	Forestry	Fisheries	Electricity, gas, steam and air conditioning supply	Total Industry	Government consumption	Household consumption	Total Use by resident economic units	Exports - final ecosystem services	Total Use by economic units	Forest	Lake	Cropland	Urban area	Wetland	Seagrass	Total use resident ecosystem assets	Exports - intermediate services	Total Use by ecosystem assets	TOTAL USE	
Selected ecosystem services																								
Provisioning services																								
	Biomass provisioning	Crop provisioning	tonnes	150				150			150		150								0	0	0	150
		Wood provisioning services	m³		140			140			140		140								0	0	0	140
		Wild fish and other natural aquatic biomass provisioning services	tonnes			9		9			9		9								0	0	0	9
Regulating and maintenance services																								
	Global climate regulation services		tonnes CO ₂					0	425		425		425								0	0	0	425
	Water purification services		tonnes N removed				7	7			7		7								0	0	0	7
Cultural services																								
	Recreation-related services		# visits					0		9,800	9,800		9,800								0	0	0	9,800

Use Table

		UNIT & OF MEASURE																				
			Agriculture	Forestry	Fisheries	Electricity, gas, steam and air conditioning supply	Total Industry	Government consumption	Household consumption	Total Use by resident economic units	Exports - final ecosystem services	Total Use by economic units	Forest	Lake	Cropland	Urban area	Wetland	Seagrass	Total use resident ecosystem assets	Exports - intermediate services	Total Use by ecosystem assets	TOTAL USE
Selected ecosystem services																						
Provisioning services																						
	Biomass provisioning	Crop provisioning	tonnes	150			150			150		150							0	0	0	150
		Wood provisioning services	m³		140		140			140		140							0	0	0	140
		Wild fish and other natural aquatic biomass provisioning services	tonnes			9	9			9		9							0	0	0	9
Regulating and maintenance services																						
	Global climate regulation services		tonnes CO ₂				0	425		425		425							0	0	0	425
	Water purification services		tonnes N removed			7	7			7		7							0	0	0	7
Cultural services																						
	Recreation-related services		# visits				0		9,800	9,800		9,800							0	0	0	9,800

Use table rows show the various ecosystem services - the same as in the supply table.

Use table rows show the various ecosystem services - the same as in the supply table.

Use table columns include economic units as well as the ecosystem assets.

Use Table

USE			TOTAL USE													
UNIT S OF MEASURE			TOTAL USE													
Selected ecosystem services			TOTAL USE													
Provisioning services			TOTAL USE													
	Biomass provisioning	Crop provisioning	tonnes	150			150			150						150
		Wood provisioning services	m³		140		140			140						140
		Wild fish and other natural aquatic biomass provisioning services	tonnes			9	9			9						9
Regulating and maintenance services			TOTAL USE													
	Global climate regulation services		tonnes CO ₂				425			425						425
	Water purification services		tonnes N removed				7			7						7
Cultural services			TOTAL USE													
	Recreation-related services		# visits				9,800			9,800						9,800

Looking at the simplified use table, it shows that the 150 tonnes of **crop provisioning services** are entirely used by the agriculture industry.

The 425 tonnes of **climate regulation services** are all used by government, which is seen in the SEEA EA to collectively consume this service on behalf of all of society (individuals, households, and businesses).

The **water purification services** are entirely used by the electricity, gas, steam and air conditioning supply industry.

Pilot ecosystem accounts in KwaZulu-Natal, South Africa

Table 5.1. Total biophysical supply per ecosystem type 2005

Resource \ Biome	Freshwater ecosystems	Grassland	Indian Ocean Coastal Belt	Savanna	Forests	Estuaries	Cultivated	Urban green space	Total
Wood products (m ³)	3 523	695 638	235 125	787 294	267 047	169			1 988 796
Non-wood products (tonnes)	834	46 494	11 489	34 952	2 911	38			96 718
Livestock production (LSU)	1 716	684 698	52 162	289 663	2 010	340			1 030 589
Crop production (tonnes)							43 305 781		43 305 781
Experiential value (R millions)	14	237	179	218	55	24	85	885	1 698
Carbon storage (Tg C)	5	512	61	348	33	0	279		1 237
Pollination (R millions)	0	12	6	31	2	0			51
Flow regulation (million m ³)	78	3 315	421	2 198	634	36			6 682
Flood attenuation (R millions)								31	31
Sediment retention (million tonnes)	2	45	6	27	18	2			99
Water quality amelioration (tonnes P)	-	3 829	525	5 394	97	6			9 850

Extended SUA for the Netherlands, 2015

[illegible]

EU Example: Physical Ecosystem Services Account

	Ecosystem types										
	Urban	Cropland	Grassland	Woodland & forest		Wetland	Heathland and shrub	Sparsely vegetated land	Rivers and lakes	Coastal /intertidal area	Total
				Available for Wood Supply	Other						
crop provision (1,000 tonne)		93,936									93,936
timber provision (1,000 m3)				885							885
crop pollination (1,000 tonne)		10,447									10,447
soil retention (mln tonne)		1,115									1,115
carbon sequestration (mln tonne)	-	-	-	306		-	-	-	NA	NA	306
flood control (1,000 hectare)	26	313	767	2,923		67	72	0,2	NA	NA	4,170
water purification (1,000 tonne)	510	13,882	2,314	3,032		73	154	45	216		20,166
habitat & species maintenance (mln euro)	NA	15,731	4,473	12,448		683	1,250	385	689	NA	35,660
nature-based recreation (1,000 nbr visits)	66	3,279	6,237	24,198		1,971	2,318	1,058	778	220	40,125

EU Example: Monetary Ecosystem Services Account

- Some of the findings are:
 - > Monetary value of 7 services assessed EUR 172 billion in 2012
 - > Forests deliver 47.5% of the total supply of the measured ecosystem services

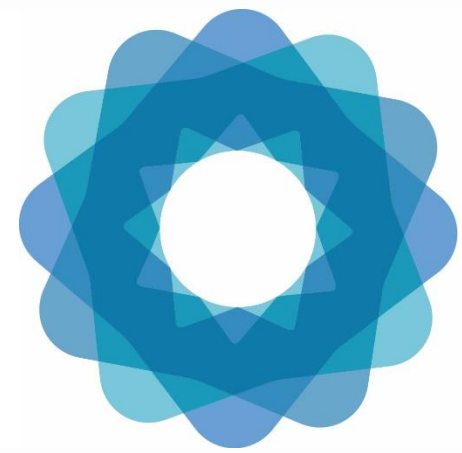
Economic value provided by ecosystem services in the EU (EU28, 2012, million EUR)

	Urban	Cropland	Grassland	Woodland and forest	Wetland	Heathland and shrub	Sparsely vegetated land	Rivers and lakes	Marine inlets and transitional waters
Crop provision	0	20 795	0	0	0	0	0	0	0
Timber provision	0	0	0	14 739	0	0	0	0	0
Crop pollination	:	4 517	:	:	0	:	0	0	0
Carbon sequestration	0	0	0	9 189	0	0	0	:	:
Flood control	89	1 015	3 129	11 388	333	357	1	:	:
Water purification	1 105	31 041	4 128	15 374	330	312	170	3 114	:
Nature-based recreation⁽¹⁾	77	4 073	7 482	30 723	2 296	3 097	1 351	1 015	279

Source: JRC

Note: (:) not available.

(1) The scope of nature-based recreation was restricted to daily trips within 4 km from human settlements and the highest natural quality sites.



System of
Environmental
Economic
Accounting

Valuation of ecosystem services and ecosystem assets



United Nations

Why is valuation important

- Zero is a poor estimate of the “monetary value of nature”, or the contribution of nature (ecosystem service)
- Look of “relatively uncontroversial numbers”
 - > Based on well-established methods
 - > Provide “minimum” values
 - > Focus on ‘use’, not ‘potential’
 - > Focus on use and ‘exchange values’

Ecosystem services

- Ecosystem services as contribution of nature
- Irrespectively of the method used, **man-made inputs need to be deducted** to arrive at the ecosystem service (as resource rent).
- Following the SEEA Central Framework:

Output

less intermediate consumption

less compensation of employees

less other taxes on production

plus other subsidies on production

Equals gross operating surplus

less consumption of fixed capital (depreciation)

less return on produced assets

less labour of self-employed persons

Equals resource rent

= depletion + net return on environmental assets

Valuation of ecosystem services

- ☐ Prices are directly observable
- ☐ Prices from similar markets
- ☐ Prices embodied in market transactions
- ☐ Prices from revealed expenditure or related goods and services
- ☐ Prices from expected expenditures and simulated markets

Valuation of ecosystem assets

- Net present value

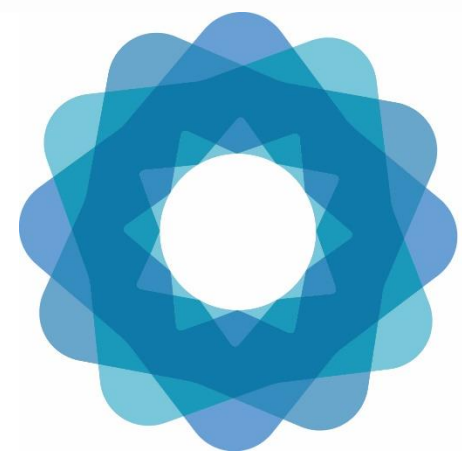
$$V_t(EA) = \sum_{i=1}^S \sum_{j=t+1}^{t+N} \frac{ES_t^{ij}(EA_t)}{(1 + r_j)^{(j-t)}}$$

where ES_t^{ij} is the value of ecosystem service i in year j as expected in period t (e.g., 2022) generated by a specific ecosystem asset EA_t ; S is the total number of ecosystem services; r_j is the discount rate (in year j) and N is the lifetime of the asset, which may be infinite for some ecosystems if used sustainably.

- In ecosystem accounting, an ecosystem asset generates a bundle of ecosystem services, each valued separately.
- The NPV formula is applied at the level of individual ecosystem services and the resulting discounted values are aggregated to derive the monetary value of the ecosystem asset.

Valuation of ecosystem assets

- The monetary ecosystem asset account records the monetary values of all ecosystem assets within an ecosystem accounting area at the beginning (opening) and end (closing) of each accounting period; as well as changes in the value of those assets over the accounting period.
- Changes in the monetary value of ecosystem assets are separated into five broad types:
 - > ecosystem enhancement
 - > ecosystem degradation
 - > ecosystem conversions
 - > other changes in the volume of ecosystem assets
 - > revaluations as a result of price changes



System of
Environmental
Economic
Accounting

Exercise!



United Nations

Some details about the services we will measure

- Carbon sequestration (look up tables)
- Crop provisioning (modeling)
- Recreation
- Water provisioning

Some details about carbon sequestration

- The carbon sequestration component of the service reflects the ability of ecosystems to remove carbon from the atmosphere.
- Assumed that carbon sequestration concerns only carbon that is expected to be stored for long periods of time. This may involve storage within an ecosystem asset, e.g., a mangrove or wetland, or another form of storage (e.g., in the economy).
- Carbon that is sequestered but not expected to be stored, e.g., crops, should be excluded from scope.
- An appropriate metric is the net ecosystem carbon balance. Where net carbon sequestration is zero or negative, the level of service supplied by an ecosystem will be zero.

Computing carbon sequestration- we will use a look up table approach!

Instructions:

Step 1 – Use the look-up table and the extent account to assess opening stocks of carbon

Step 2 – Use the look-up table and the extent change matrix to assess carbon uptake by biomass (i.e. assume that carbon uptake is only taking place in cells that are not converted from one ET to another)

Step 3 – For all converted areas make the assumption that the conversion takes place completely during the accounting period (e.g. the change in carbon stocks from forest to crops is $200 - 40 = 160$).

Step 4 – Assume a forest fire takes place in EA02 that reduced the stocks from 215 to 25 for 4 BSUs.

Step 5 – Calculate the net changes. These net changes are called NECB (net ecosystem carbon balance – which is the metric proposed (aligned with IPCC guidelines) to estimate carbon sequestration.

Step 6 – Calculate the closing stocks.

Computing carbon sequestration

Look up table	Carbon storage (tC/ha)	Carbon uptake by biomass (tC/ha)
Urban and industrial	5	1

40	40	200	200	200		5	5	5
40	5	5	5	5		5	5	5
40	5	5	5	5		5	5	5
40	5	5	5	300	300			
200	200	200	200	300	300	40	40	40

200	215	215	215		44	44	44	44
200	215	215	215		44	44	5	5
44	215	215	215		6	6	6	5
6	6	6	6		6	6	6	44
6	6	6	6		6	6	6	44
6	6	6	324	324				
215	215	215	324	324	44	44	44	44

Simplified Carbon Stock Account

	Urban and industrial
Opening extent (ha)	20
Closing extent (ha)	23
Opening	100
Addition - carbon uptake by biomass	20
Addition - conversion	15
Reduction - forest fire	0
Reduction - conversion	0
Net Ecosystem Carbon Balance (NECB)	35
Closing	135

Computing carbon sequestration

Simplified Carbon Stock Account

	Urban and industrial	Annual croplands	Tropical heath forest	Large lowland rivers	Coastal river delta	Total
Opening extent (ha)	20	153	90	19	6	288
Closing extent (ha)	23	145	96	19	5	288
Opening	100	6,120	18,000	0	1,800	26,020
Addition - carbon uptake by biomass	20	568	1,320	0	120	2,028
Addition - conversion	15	120	1,600	0	0	1,735
Reduction - forest fire	0	0	760	0	0	760
Reduction - conversion	0	440	400	0	300	1,140
<i>Net Ecosystem Carbon Balance (NECB)</i>	35	248	1,760	0	-180	1,863
Closing	135	6,368	19,760	0	1,620	27,883

Some details about modeling crop provisioning

We have consulted with agronomists and they have informed us that there is a linear relationship between rainfall and amount of crops produced.

We know the crop production for EA11 (we will find out later)

Assume that the total crop yield in EA01 was 18,700 tons/year.

Step 1: Calculate average rainfall for EA01 taking into consideration that EA01 spreads across 2 rainfall zones.
Additional detail—10 hectares of EA01 are in the 190mm/yr zone

Step 2: Calculate yield per ha for EA01

Step 3: Calculate yield per ha for EA04 based on the biophysical model

Step 4: Aggregate across whole extent of EA04.

Some details about modeling crop provisioning

We have consulted with agronomists and they have informed us that the ratio of rainfall to crop yield is the same for EA01 and EA04

We know the crop production for EA11 (we will find out later)

Assume that the total crop yield in EA01 was 18,700 tons/year.

Step 1: Calculate average rainfall for EA01 taking into consideration that EA01 spreads across 2 rainfall zones.
Additional detail—10 hectares of EA01 are in the 190mm/yr zone

Step 2: Calculate yield per ha for EA01

Step 3: Calculate yield per ha for EA04 based on the biophysical model

Step 4: Aggregate across whole extent of EA04.

Finalizing the service supply table!

The objective is to fill out all empty cells in the service supply table.

Step 1: use information from the carbon account to fill out the information on carbon sequestration. Keep in mind what is in scope and what is out of scope

Step 2: fill out the information on crop supply for EA04 (orange cell)

Step 3: estimate the remaining values from nearest neighbour for (C), (R) and (W) for the missing EAs; e.g.,
 $\text{Crop for EA11} = \text{Crop for EA01} / 80 * 28.$

Step 4: Calculate totals for each service

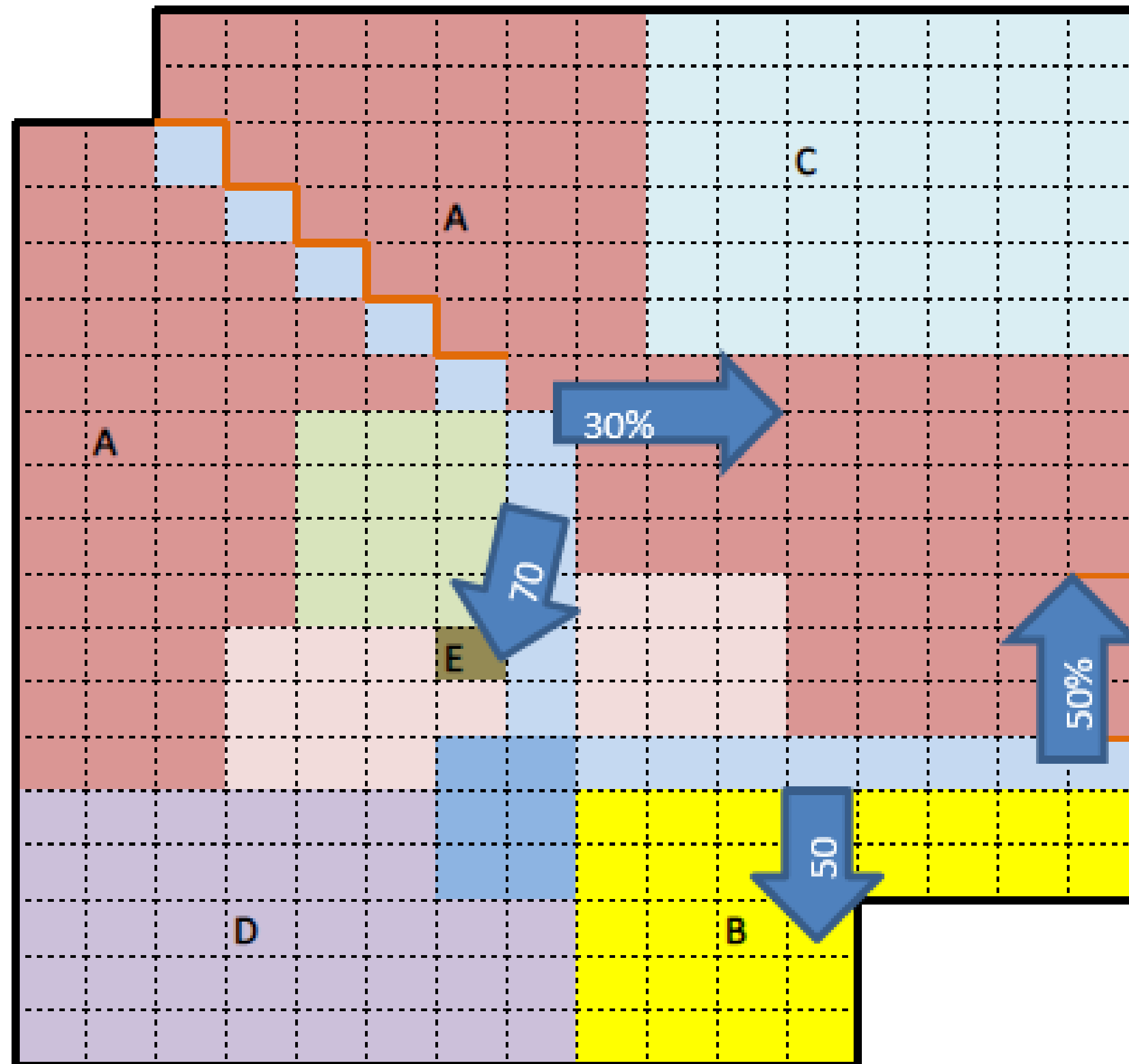
Step 5: Aggregate the results by ET in the table below.

Finalizing the use table!

- Assume that all visits to the forest EA10 (i.e. D) are for a campsite; rest are by households (they are the users and beneficiaries)
- Water use allocation percentages are indicated in the figure (next slide).
- Check your answer as supply needs to equal use (for each individual ecosystem service)!

Services Use Account					
		(C) Crop	(R) Recreation	(W) Water	(S) Carbon Sequestration
Beneficiaries (based on survey)		Tonnes	Trips	m³	tonnes
Agriculture - cereals					
Agriculture - other					
Water supply sector					
Recreation					
Households					
Government					
Total		-	-	-	-

Finalizing the use table!



Eco ISIC - Classification of economic activities

- A 0111 - Growing of cereals (except rice), leguminous crops and oil seeds
- B Other agriculture
- C 0113 - Growing of vegetables and melons, roots and tubers
- D 5520 - Camping grounds, recreational vehicle parks and trailer parks
- E 36 - Water collection, treatment and supply
- F Households
- G Government

THANK YOU

seea@un.org // <https://seea.un.org/>

