System of Environmental Economic Accounting

Carbon Accounting

Training Workshop on an Accounting Approach to Climate Change and Biodiversity in Central Asia

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What information do we need to inform climate change policy?

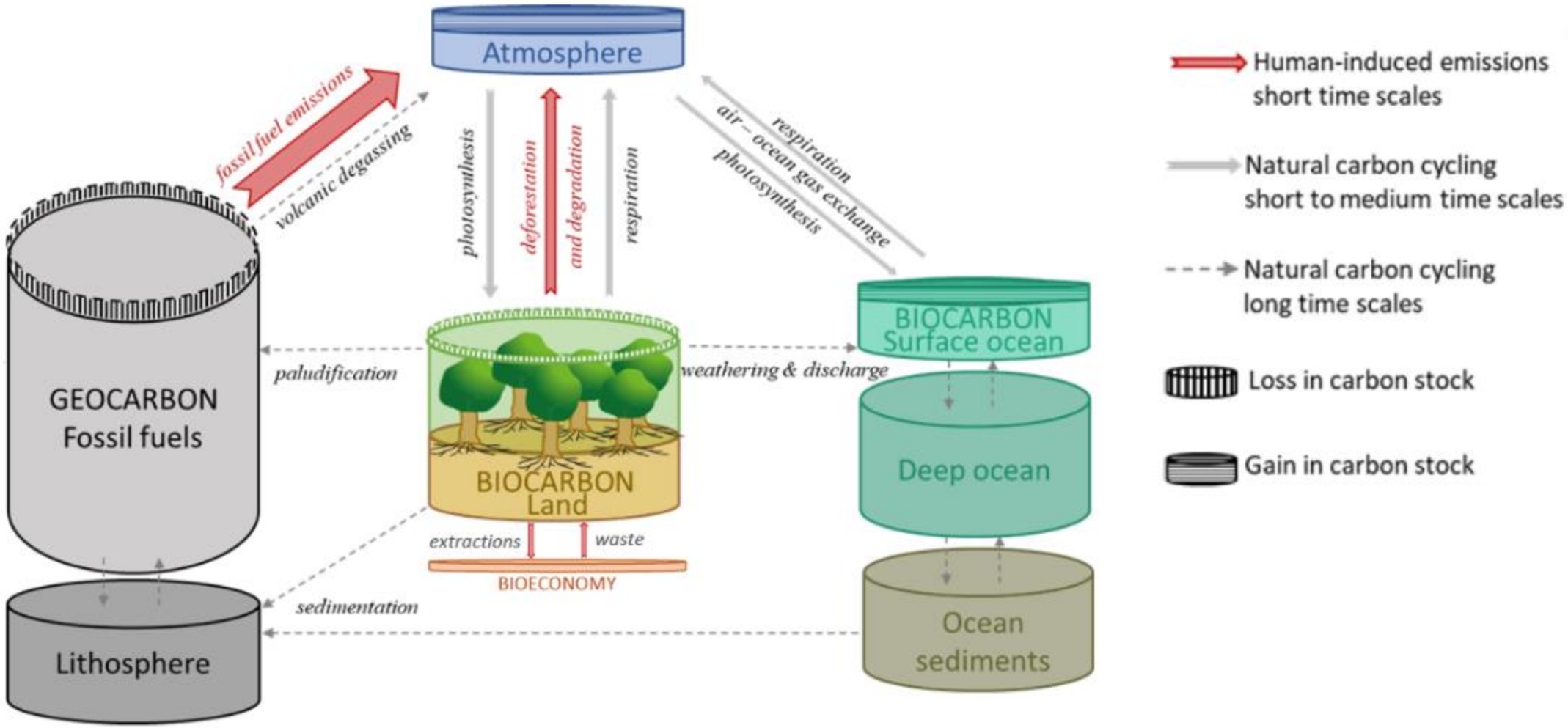
- We need to understand the relationship between the economy and climate change-> need good data to inform our understanding and what we need to do to mitigate and adopt!

- SEEA is the statistical framework that allows us to link economic activity and the many facets of climate change.

- More broadly, an integrated data approach is needed.

Global carbon cycle

understanding natural and human drivers



[drawn to scale except for the large carbon stocks in the lithosphere and deep ocean]

SEEA and Climate Change

Various climate related policies can be informed by various types of SEEA accounts:

- Informing **mitigation and adaptation strategies**
- Providing a comprehensive overview of how much **carbon is stored per ecosystem type** and how this develops over time
- Assessing how **climate change impacts** economic activities and households
- A proposed new **Data Gaps Initiative** (under the auspices of the G20 Finance Ministers and Central Bank Governors)
  - > 4 priorities endorsed: a.o. Climate Change;
  - > SEEA air emission accounts and energy accounts included

United Nations Framework Convention on Climate Change

Accounting for carbon in the SEEA

- Ecosystem service accounts
  - > Global climate regulation service
- Thematic accounts
  - > Carbon stock account
- Land accounts
    - Land Use, Land-Use Change and Forestry (LULUCF)

Carbon stock account

- Comprehensive coverage of all relevant carbon stocks and changes in stocks
  - > Covers geosphere, biosphere, atmosphere, oceans and economy
- Note: broader in coverage than global climate regulation (e.g. includes oceans) and broader than SEEA EA (i.e., economy)
- Especially useful for land-use policies and ocean policy
  - > Record depletion of carbon and resulting CO2 emissions due to land use conversion or changes due to ocean policies
  - > Indicate what land could be prioritized through reforestation/restoration to restore carbon stocks

Carbon stock account

	Geocarbon					Biocarbon			Carbon in the economy			Carbon in the oceans	Carbon in the atmosphere	Total
	Oil	Gas	Coal	Limestone and marl	Other	Terrestrial	Freshwaters and saline wetlands	Marine	Inventories	Fixed assets, consumer durables	Waste	Total	Total	
Opening stock														
Additions to stock														
Unmanaged expansion														
Managed expansion														
Discoveries														
Reclassifications														
Imports														
Reductions in stock														
Unmanaged contraction														
Managed contraction														
Reclassifications														
Exports														
Catastrophic losses														
Net carbon balance														
Closing Stock														

- Unmanaged: Changes due to natural growth/loss or indirect effects of human activity
- Managed: Changes due to human-managed growth/contraction in ecosystems and economy
- Discoveries: Usually applicable to geocarbon and arises through exploration/evaluation
- Reclassifications: Carbon asset used for a different purpose and is thus reallocated to different stock category.
- Imports/exports: imports/exports of produced goods containing carbon

Example from the Netherlands (2018)

	Geocarbon						Biocarbon				Carbon in the economy				Carbon in the atmosphere	Total
Mton C	Crude oil	Natural gas	Shale gas	Coal	Limestone	**Total geocarbon**	Forests	Cropland / meadows	Other ecosystems	**Total biocarbon**	Inventories	Fixed assets, cosumer durables	Waste	**Total in the economy**	**Total in the atmpshere**	
Opening stock	32	394	94	12717		**13238**	61	203	106	**370**	20	0	0	**20**	**3094**	**16721**
																0
Additions to stock	1	0				**1**	1	7	0,2	**9**	245	3	22	**270**	**62**	**342**
Unmanaged expansion							1	0,2	0,2	**2**					**2**	**4**
Managed expansion								7		**7**	24			**24**	**60**	**91**
Discoveries	0	0		0		**0**										**0**
Upwards reappraisals	1	0		0		**1**										**1**
Reclassifications											21	3	13	**37**		**37**
Imports											201		8	**209**		**209**
																0
Reductions in stock	1	254		0	0,1	**255**	1,0	8	0,6	**10**	242	1	20	**263**	**9**	**536**
Unmanaged contraction							0,1	1	0,6	**2**					**2**	**4**
Managed contraction	1	17		0	0,1	**18**	0,9	7		**8**	58		3	**60**	**7**	**93**
Downwards reappraisals	0	237		0		**237**										**237**
Reclassifications											25	1	11	**37**		**37**
Exports											159		6	**165**		**165**
																0
Net carbon balance	0	-254		0	-0,1	**-254**	0,3	-1	-0,4	**-1**	3	2	2	**7**	**54**	**-194**
																0
Closing stock	32	140	94	12717		**12984**	61	202	105	**369**	23			**27**	**3148**	**16527**

Additions less reductions in stock

From Statistics Netherlands: https://unece.org/sites/default/files/2023-03/S8_4_NL_Carbon%20account.pdf

Global climate regulation service (carbon)

- How to frame carbon-related ecosystem services?
  - Need to provide right incentives, correct policy signals
- Global climate regulation service in SEEA EA considers two components:
  - **carbon sequestration**: the ability of ecosystems to remove carbon from the atmosphere
  - **carbon retention**: the ability of ecosystems to retain the stock of carbon – i.e., ecosystems supply a service through the avoided emission of carbon to the atmosphere
- Services reflect ecosystems contribution to reducing concentrations of GHG in the atmosphere and stabilizing the climate, in turn avoiding damages that arise due to climate change.
- If there is a clear expansion in the stock of carbon, carbon sequestration may be of more interest
- In many cases though, stocks of carbon are at risk of emission—which means that carbon retention is more helpful

Measurement boundaries: carbon retention

- Total stock of carbon is very large, especially in certain types of ecosystems➔ SEEA EA specifies a number of measurement boundaries when it comes to carbon retention:
- For example (see SEEA EA for details):
  - > Stocks are limited to carbon stored in above ground and below ground living and dead biomass and soil organic carbon;
  - > Excluded from scope: inorganic carbon stored in freshwater, marine and subterranean ecosystems;
  - > Carbon stored in fossil fuel deposits **should not** be considered an ecosystem service, as these deposits are not part of ecosystem assets;
  - > Excluded: Carbon stored in cultivated biological resources that have a short rotation cycle (e.g., crops).

Measuring carbon sequestration

- Reflects ability of ecosystems to remove carbon from the atmosphere:
  - > Only concerns carbon that is expected to be stored for a long period of time—either within an ecosystem asset or in the economy;
  - > Carbon that is sequestered but not expected to be stored (e.g. crops) should be excluded;
- Carbon retention and sequestration are distinctly different services, but there are connections
  - > Increase in carbon sequestration = increase in carbon stock and carbon retention
  - > However, sequestration in any single year is only a small fraction of carbon retained ➔ for accounting purposes, SEEA EA sees these as related but distinct

Modeling carbon sequestration and retention

- Two basic approaches for sequestration
  - #1 Derive sequestration by comparing changes in stocks of carbon over time, e.g. using forest inventories and soil carbon measurements (aka 'stock-difference method' in IPCC guidelines)
    - Indirect method, as sequestration is derived as a residual
  - #2 Estimate carbon sequestration directly by quantifying all key inflows and outflows of carbon per ecosystem unit/asset (e.g. including plant and soil respiration, carbon loss from land disturbance, etc)
    - Called Gains-Loss method in IPCC guidelines
- Retention
  - First approach is usually preferred—easier and also provides information on retention—stocks for each year are proxy for carbon retention.

Modeling carbon sequestration and retention

- Different data sources for each method can be used depending on data availability (see Biophysical Guidelines for details)
  - Tier 1 (stock-difference): Uses IPCC default carbon coefficients and other parameters.
    - InVEST carbon storage and sequestration models
    - ARIES for SEEA global climate regulation models
  - Tier 2 (stock-difference): Same methodology/approach as Tier 1, but uses country-specific coefficients and parameters
  - Tier 3: Bespoke models and plot-level data from National Forest Resource Assessments (FRAs).
    - Likely integrates data sources from different types of monitoring
    - Either stock-difference method or gains-loss method

ARIES for SEEA
for rapid, standardized account creation

- Global, customizable models approach enables:
  ⟹ **SEEA EA compilation**[1]
- **Faster & easier** to learn than other biophysical modeling approaches
- **Automate production** of accounting tables, maps & reports
- Support adoption of SEEA EA providing an **easy-to-use application**
- Infrastructure for the SEEA community to **share & reuse** interoperable data & models

SEEA

1: anywhere on the earth with global data,
but models can be improved using local data (and models) where available.

Global Climate Regulation

Total ecosystem carbon storage is computed as **the sum of the carbon mass stored in aboveground and belowground vegetation**, plus the amount stored in the first 200 cm of **soil**. The results are expressed in CO_2 tons/he

Methodology

Vegetation carbon storage (summed aboveground and belowground biomass carbon), using a multilayer lookup table[1] based on:

I. Land cover type
II. Ecofloristic region (FAO classification)
III. Continental region
IV. Presence of frontier forests (i.e., intact forest landscapes a proxy for forest age)
V. Recent occurrence of fires

Caveats to the Ruesch and Gibbs model

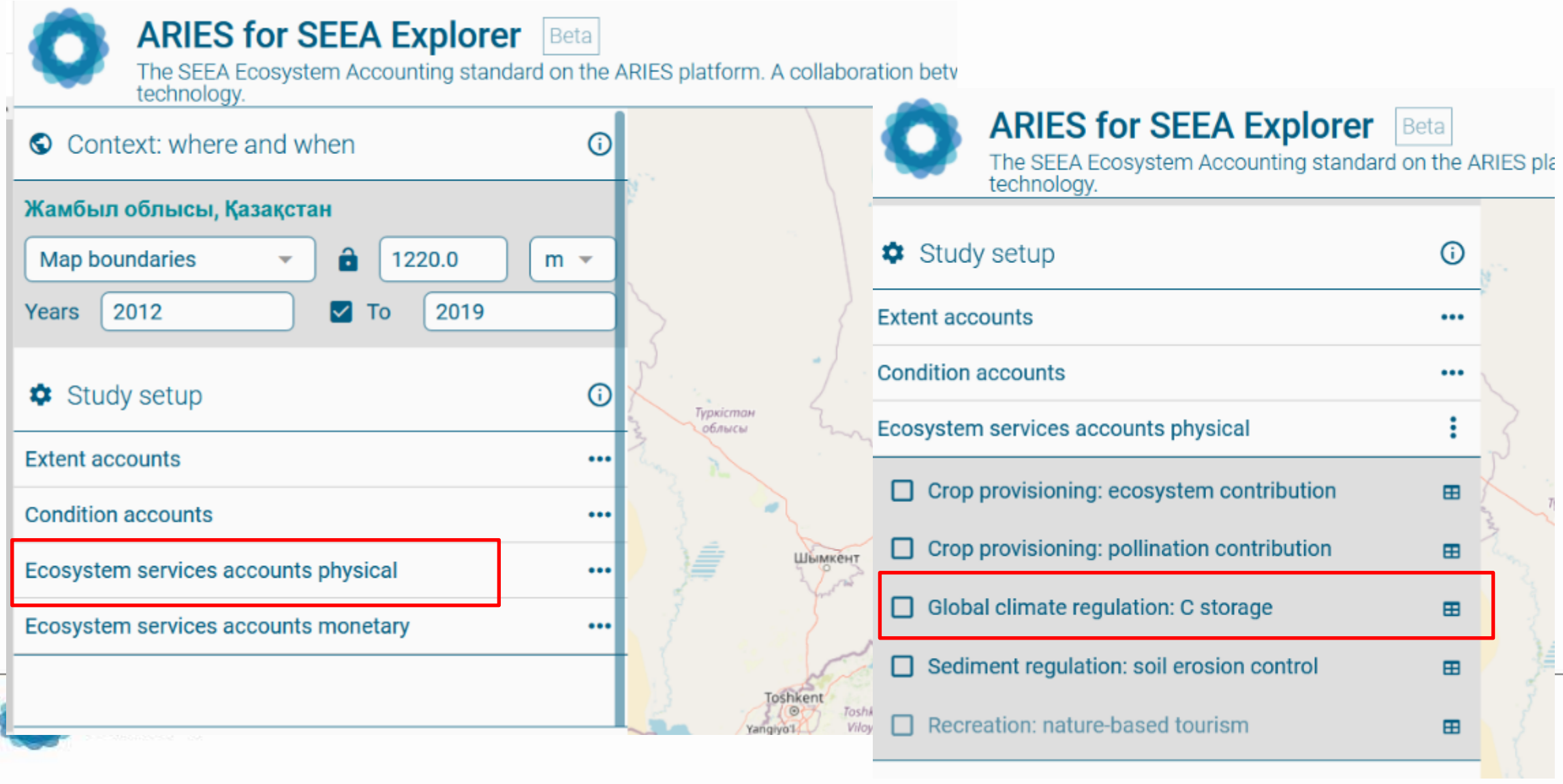
- Does not account for **forest age** or **successional stage** (aside from presence of frontier forests and burned areas)
- Potential **errors at the edges** of continents or ecoregions
- Data are not provided for carbon storage in wetlands
- Introduce a model to address this limitation in mangroves

1: This method was first published by **Ruesch,** Aaron, and Holly K. Gibbs. **2008**. New IPCC Tier-1 Global Biomass Carbon Map for the Year 2000. Available online from the Carbon Dioxide Information Analysis Center [http://cdiac.ornl.gov], Oak Ridge National Laboratory, Oak Ridge, Tennessee

Simplified version of multi-layer look-up table to model above & belowground carbon storage

land_cover_type	ecofloristic_region	continental_region	frontier_forest	burned_land	carbon_stock
landcover:BroadleafForest	ecology:TropicalRainforest	geography:AfricanRegion	*	false	200
landcover:BroadleafForest	ecology:TropicalRainforest	geography:NorthAmericanRegion	*	false	193
landcover:BroadleafForest	ecology:TropicalRainforest	geography:SouthAmericanRegion	*	false	193
landcover:BroadleafForest	ecology:TropicalRainforest	geography:AsianRegion	*	false	180
landcover:BroadleafForest	ecology:TropicalRainforest	geography:InsularAsianRegion	*	false	225
landcover:BroadleafForest	ecology:TropicalRainforest	geography:AustralianRegion	*	false	199.5
landcover:BroadleafForest	ecology:TemperateContinentalForest	geography:AsianRegion	false	false	14
landcover:BroadleafForest	ecology:TemperateContinentalForest	geography:EuropeanRegion	false	false	14
landcover:Forest	ecology:BorealMountainSystem	*	false	true	4.5
landcover:BareArea	*	*	*	*	1
landcover:WaterBody	*	*	*	*	0
landcover:ArtificialSurface	*	*	*	*	0

ARIES for SEEA: Global climate regulation



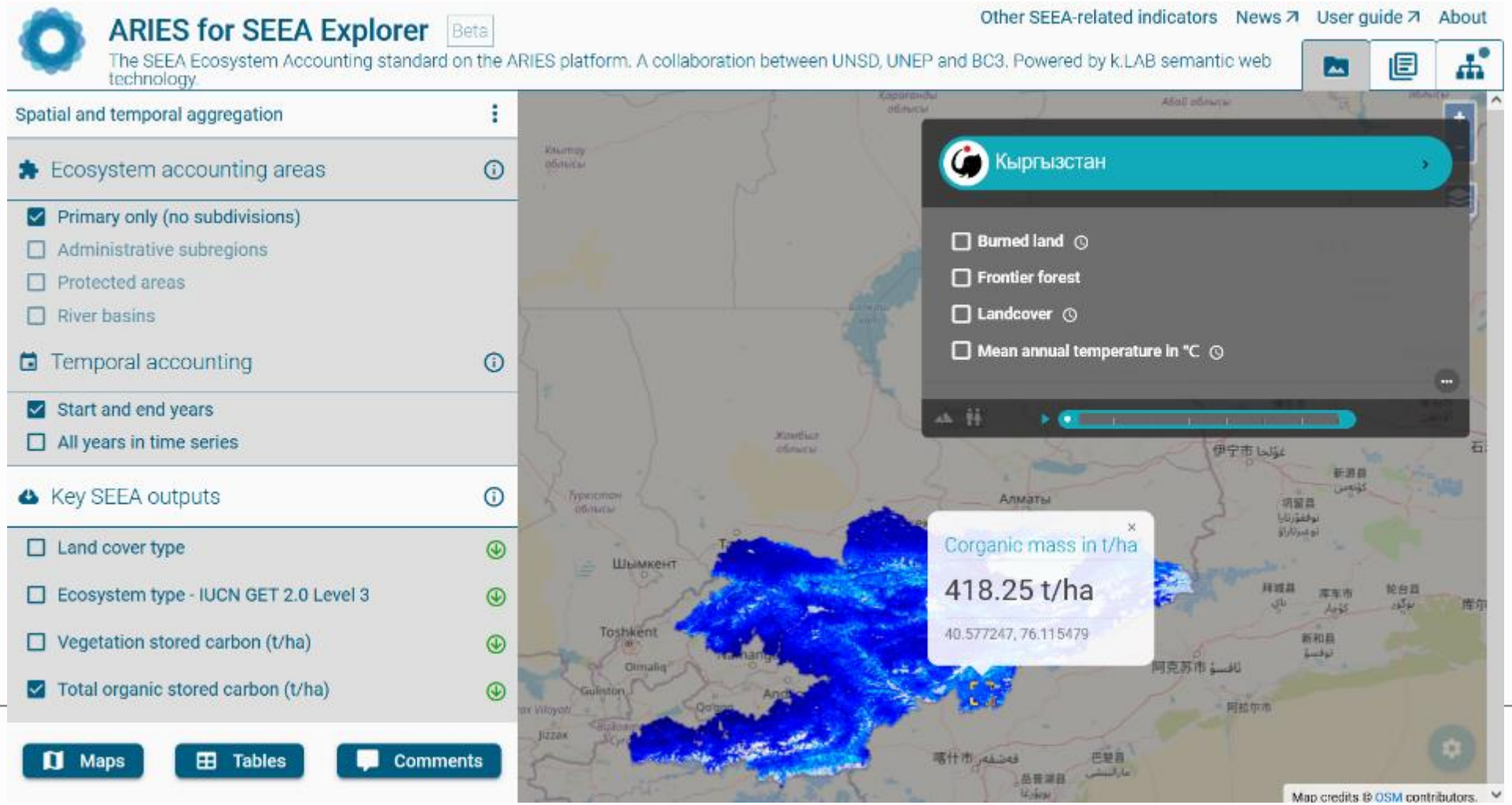
Tabular output

Table 1. Global Climate Regulation Physical Supply (tons C storage)

	A	B	C	D	E	F	G	H	I
1	**Table 1. Global Climate Regulation Physical Supply (tons C storage)**								
2		Alpine grassland shrubland	Boreal temperate montane forest woodland	Cool desert semidesert	Cool temperate heathland	Cropland	Ice sheet glacier permanent snowfield	Other desert semidesert	Polar alpine rocky outcrop
3	Year 2012	2952599.9	3315172.0	626849.7000000	2.83410601499	1.58234185E7	267736.0	228802.2999999	4077712.0
4	Year 2018	2908422.4	3627058.5	580647.0000000	2.79931699499	1.572074525E7	267736.0	279053.4999999	4089233.0
5	Net change	-44177.5	311886.5	-46202.7000000	-347890.199999	-102673.25	0.0	50251.1999999	11521.0
6									

Map view

Total organic carbon storage in t/ha



SEEA