System of Environmental Economic Accounting

Carbon Accounting

Regional Workshop for an Accounting Approach to Climate Change Statistics and Indicators

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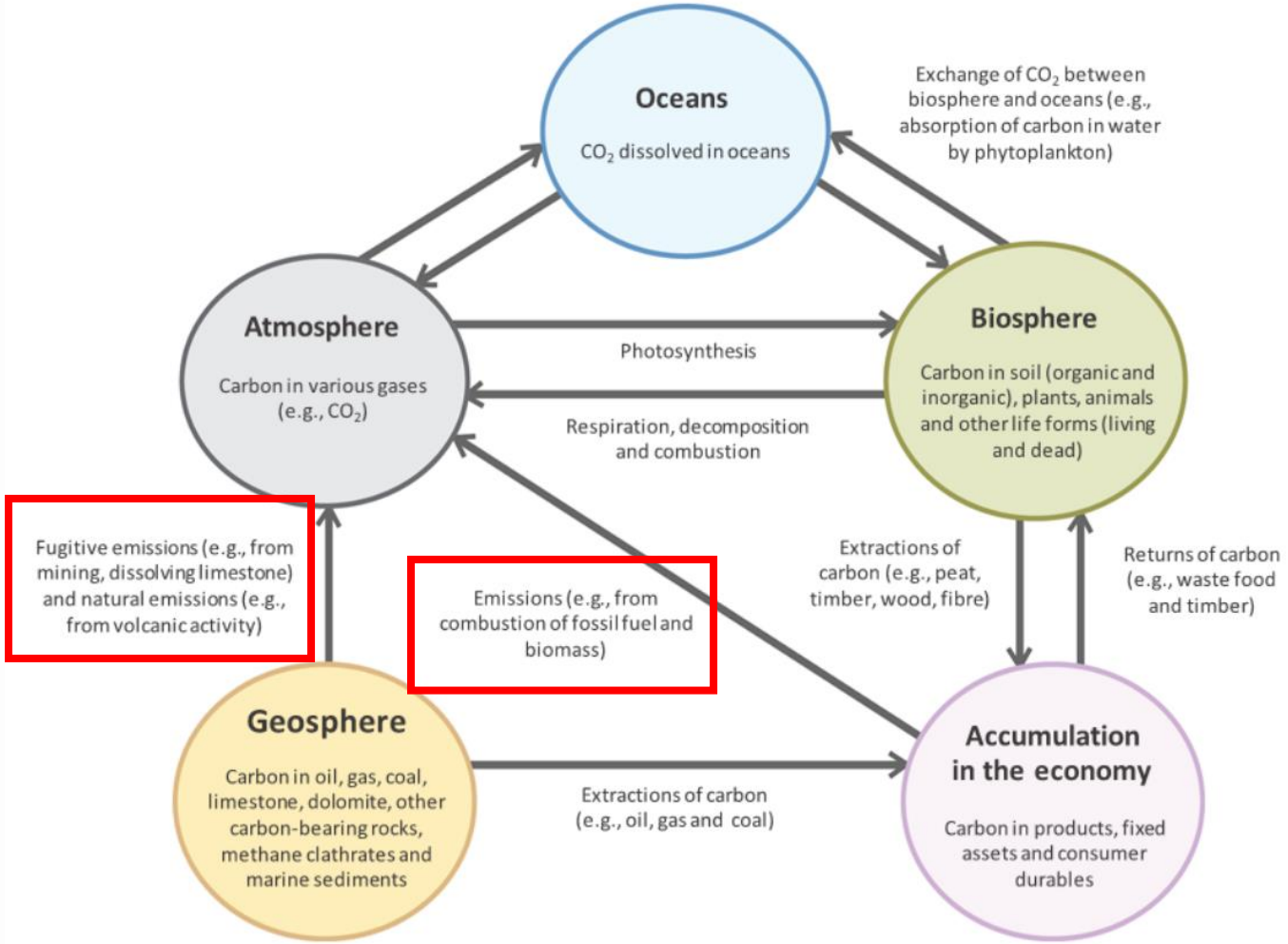
Accounting for carbon in the SEEA

- Measurement and analysis of climate change commonly focuses on the emission of GHGs
- But this aspect of climate change is only one part of the overall carbon cycle
- Ecosystems (terrestrial and oceans) play a key role in mitigating climate change through removing carbon from the atmosphere and storing it



Accounting for carbon in the SEEA EA

- Ecosystem service accounts
  - Global climate regulation service
- Thematic accounts
  - Carbon stock account

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

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

Exercise set up: Calculating carbon retention – basic approach

- Use default coefficients in IPCC guidelines to obtain estimates for vegetational and soil organic carbon for forests
  - 1. Identify IPCC coefficients for soil organic carbon, above ground biomass and below ground biomass (tonnes dry matter/ha), which differs according to LC/forest type
    - E.g. primary tropical rainforest has 45.6 tonnes of AGB/ha
  - 2. Multiply this coefficient by the carbon coefficient (default, 47% of biomass is carbon) to obtain tonnes carbon/ha
    - Our primary tropical rainforest has 21.4 tonnes C/ha stored in above ground biomass
  - 3. Multiply this by total extent of forest to obtain total carbon stored in AGB/ha
  - 4. Similar calculations for below ground biomass (BGB) (and soil organic carbon)
  - 5. Carbon stored (tC) x price ($/tC) = avoided damage

Exercise set up

- Welcome to the Asian country of Seelandia, where deforestation is a growing concern
- The government would like some quick numbers to understand how much carbon is retained each year by the country's forests and the value of this service.
- The government does not have any country-specific carbon coefficients or studies for biomass.
- However, they do have information on the extent of their forests according to data layers for management type, ecological zone and status/age. They also have soil organic carbon coefficients for these different strata of forests.
- Seelandia officials decide to use the basic approach to calculate carbon retention.

Natural forest type

	Status		
Ecological zone	*Primary*	*Secondary > 20 yrs*	*Secondary <= 20 yrs*
Tropical rainforest	9204	1536	42367
Tropical shrublands (moist)	2878	15011	8134
Tropical mountain systems	9736	16357	34761

Plantation forest type

	Species		
Ecological zone	*Broadleaf*	*Palm*	***Note: Assume all plantations are less than 20 years old**
Tropical rainforest	3843	8548	
Tropical shrubland (moist)	0	0	
Tropical mountain systems	0	0	

Exercise steps

1. All calculations are done on the "Carbon stocks 2020" sheet
2. Obtain the extent of each forest stratum from the worksheet "Forest extent"
   - E.g. primary natural tropical rainforest, etc.
3. For soil carbon, multiply the forest stratum extent with the coefficient for soil organic carbon (provided!) to arrive at total soil organic carbon by stratum
4. For above ground biomass (AGB) stocks, obtain the coefficients for dry matter per hectare from Table 4.7 OR 4.8. To arrive at total carbon for AGB per stratum, multiply the extent with the coefficient for dry matter and the carbon fraction (provided!).
5. For below ground biomass (BGB) stocks, obtain the "root to shoot" ratio from Table 4.4. To arrive at total carbon for BGB, multiply the "root to shoot" ratio with the coefficient for AGB dry matter/ha, the carbon fraction (provided!) and the extent of the stratum (ha).
6. Calculate the avoided damage.

https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/4_Volume4/19R_V4_Ch04_Forest%20Land.pdf

N.B.: Assume all plantations in Seelandia are less than 20 years old

Exercise solution and discussion

- Total physical stock in Seelandia: 15,837,321.59 tonnes of Carbon retained in 2020
- Monetary value / total avoided damages : $2,103,726,662.95 USD
- Discussion:
  - How to present this data or use it in combination with other data?
  - Benefits/disadvantages to using the social cost of carbon?