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Carbon sequestration: Forest and soil

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1. Introduction

This issue paper is closely related to the paper on issue 21.a. 'Classification of forests'. The objective of the paper is to give a general picture on possibilities to achieve standard for accounts for carbon sequestration in the revised SEEA.

The paper is focused on applicability of two basic set of frameworks and information on carbon sequestration of forests and other land categories that can be used for the SEEA accounts. The first set is Category 5. The Land use, land use change and forestry (LULUCF) in reporting greenhouse gases according to the UN climate convention and the Kyoto protocol. This is included into Intergovernmental Panel on Climate Change (IPCC) Good Practice Guidance for LULUCF and UNFCCC Guidelines on annual inventories. The second set is Categories, definitions and specifications of Global Forest Resource assessment (FRA) of the Food and Agricultural Organisation (FAO), which are briefly presented in the paper 'Classification of forests'.

2. Land use, land use change and forestry in greenhouse gas reporting

In reporting greenhouse gases according to the UN climate convention and the Kyoto protocol, the main greenhouse gas (GHG) source and sink category related to forests and other land covers is category 5. Land use, land use change and forestry. This category is further sub-divided into:

Forest land,
Cropland,
Grassland,
Wetlands,
Settlements and
Other land.

The Forest land consists of:

1. Forest land remaining forest land
    - 1.1. Managed (intensively/extensively)
    - 1.2. Natural, undisturbed
2. Land converted to forest land
    - 2.1. Managed (intensively/extensively)
    - 2.2. Natural, undisturbed

The GHG reporting covers only managed forests. Managed forests are subject to periodic or ongoing human interventions, including full range of management practices from commercial timber production to stewardship in non-commercial purposes. Division between intensively and extensively managed forest is a tool in defining conversion factors of carbon binding. Forest Land Remaining Forest Land are forest areas which have been forests for at least 20 years. Land Converted to Forest Land are lands converted more recently to forests by natural or artificial regeneration, afforestation or reforestation.

Carbon pools in the GHG reporting are Living Biomass, Dead Organic Matter and Soils. For these pools changes in carbon stock are calculated. In addition to that, N_2O and CH_4 emissions are calculated for forest fires, and N_2O emissions also for soil organic matter mineralization, nitrogen inputs and cultivation of organic soils.

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For the forests the key entity is **annual change in carbon stock.** It is the sum of:

Change in carbon stocks in living biomass
+ Increase due to above and below ground biomass growth
- Decrease due to fellings, fuelwood gathering, disturbances
Change in carbon stocks in dead wood and litter
Change in carbon stocks in mineral and organic soil

Equation for the change of carbon stock in the forests is presented at detailed level in the picture 2.1. Equations to changes in carbon stocks of cropland, grassland, wetlands, settlements and other land are also available from the IPCC Good Practice Guidance for LULUCF, as well as instructions for calculations.

Picture 2.1. Change in carbon stock of forests

Annual change in carbon stocks =
+ Annual change in carbon stocks in living biomass (above- and belowground biomass) =
+ Increase due to biomass growth
Above ground biomass increment (stem, stump, branches, bark, seeds, foliage)
Below ground biomass increment (live roots)
- Decrease due to biomass lost
Loss due to commercial fellings (extracted volume, fraction of biomass left to decay in forest)
Loss due to fuelwood gathering (volume, density, expansion factor to total biomass a.ground)
Other losses (due to disturbances)
+ Annual change in carbon stocks in dead organic matter (dead wood and litter)
Change in carbon stock in dead wood (standing, lying in the ground, in the soil)
Change in carbon stock in litter (litterfall; leaves, twigs, small branches, fruits, flowers, bark, (-)decomposition)
+ Annual change in carbon stocks in soils
Change in carbon stock of mineral soil (organic fraction of mineral soil)
Change in carbon stock of organic soil

3. Carbon stock in the Global Forest Resource assessment (FRA)

In the FRA, information on carbon stock indicates the contribution of Forest and Other wooded land to the carbon cycle. This information is used by international processes that monitor greenhouse gases and climate change. Unit of reporting is Million metric tonnes, and reported figures refer Area classified as Forest and as Other wooded land.

In order to harmonise with ongoing international processes and to reduce the reporting burden, the categories and definitions used in FRA correspond to those established by the Intergovernmental Panel on Climate Change (IPCC). Categories of carbon stock of forest in the FRA are presented in the table 3.1.

Carbon content in biomass is usually derived using conversion factors. The reported figures on carbon stock are therefore closely related to corresponding figures on biomass stock and growing stock. Conversion factors from timber and biomass stock are not directly used for carbon stock changes of the soil. An example of conversion factors is given in the table 3.2.

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Table 3.1. Categories of carbon stock of forest in the FRA

T 8 Carbon stock	
Carbon in above-ground biomass	Carbon in all living biomass above the soil, including stem, stump, branches, bark, seeds, and foliage.
Carbon in below-ground biomass	Carbon in all biomass of live roots. Fine roots of less than 2 mm diameter are excluded, because these often cannot be distinguished empirically from soil organic matter or litter.
Carbon in dead wood	Carbon in all non-living woody biomass not contained in the litter, either standing, lying on the ground, or in the soil. Dead wood includes wood lying on the surface, dead roots, and stumps larger than or equal to 10 cm in diameter or any other diameter used by the country.
Carbon in litter	Carbon in all non-living biomass with a diameter less than the minimum diameter for dead wood (e.g. 10 cm), lying dead in various states of decomposition above the mineral or organic soil.
Soil carbon	Organic carbon in mineral and organic soils (including peat) to a specified depth chosen by the country and applied consistently through the time series.

Table 3.2. An example of conversion factors. Finland 2009.

Conversion factors:

Species	ef	dw(Mg/m3)	cc	cf(MgC/m3)
pine	1,527	0,39	0,519	0,3091
spruce	1,859	0,385	0,519	0,3715
non-coniferous	1,678	0,49	0,505	0,4152

Conversion equation: cf = ef * dw * cc
ef = expansion factor from stem volume to total tree biomass
dw = conversion factor to dry matter
cc = C-content
cf = conversion factor from stem volume to total biomass C content

4. Conclusions to be considered

The GHG reporting on changes of carbon stocks cover only managed forests. This category equals to the FRA categories Other naturally regenerated forest and Planted forest. From the SEEA assets point of view, timber in those above mentioned forest categories equals to the SEEA asset category EA.1411 Cultivated (timber resources). Therefore, changes in the carbon stock of cultivated timber resources can directly be derived from the FRA and GHG reporting on timber, tree biomass and carbon. For the category EA.1412 Non-cultivated (timber resources), same conversion factors from cubic metres of timber to tons of carbon of the whole biomass of trees than for cultivated timber can be used.

For the SEEA asset accounts for forests, changes in the stock of carbon in forests consisting of Non-cultivated timber are as important as those changes in forests consisting of Cultivated timber. The scope of the SEEA exceeds the scope of the GHG reporting framework. Additional information and/or estimation methods on changes in the carbon stock of soil is needed for Primary forests that consist of Non-cultivated timber and wood biomass, in order to get a full picture on carbon sequestration to the whole SEEA asset category EA.231 Forested land.

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In general, changes in carbon stock of timber, rest of wood biomass and forest soil can be included into the SEEA asset accounts for forested land and timber. Rough estimates for annual opening and closing stocks of carbon can be derived from data and estimations on annual changes in stocks.

However, it should be considered whether full balance sheets on carbon stocks are important for the SEEA standard, or would it be enough at this stage of the revision to concentrate only to changes of carbon stocks. Changes in stocks offer information for the decision making on optional uses of forests, such as e.g. intensive timber production or protection of forests to prevent climate change.

Carbon removal of forest from the atmosphere (forests as a sink of carbon) can be seen as an ecosystem service provided by the forest. Although e.g. data on actual emission trading values give some basis for estimation of monetary value of this service, it seems that valuation of carbon stocks and changes in the stocks is still not mature enough for the SEEA standard of forest asset accounts.