DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS
STATISTICS DIVISION
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System of Environmental Economic Accounting

SEEA Central Framework 2028 update

Draft Guidance Note

D1: Carbon Stock Account

Version for discussion at the SEEA CF Technical Committee meeting on 17-21 November 2025.

GUIDANCE NOTE: Carbon stock account

1 Introduction

1.1 Purpose of the Guidance Note

1. The aim of this Guidance Note is to outline the relevant considerations concerning SEEA Central Framework (SEEA CF) update issue D1 on the inclusion of a description of the carbon stock account in the SEEA CF. The broad proposal for consideration is whether the current content and description of a carbon stock account that is presented in Chapter 13 of the SEEA Ecosystem Accounting (SEEA EA) should be transferred to the SEEA CF; and if so, what changes to that content should be recommended.
2. The carbon stock account is introduced and described in detail in the SEEA EA (Section 13.4 and Annex 13.2 – content is provided in Annex 1 below). This content built on initial descriptions presented in the SEEA Experimental Ecosystem Accounting (SEEA EEA) in 2013. In short, the carbon stock account organizes data for an accounting period on the stocks of carbon (opening and closing stocks), additions to stock and reductions in stock across all carbon reservoirs, namely Geosphere, Biosphere, Atmosphere, Oceans and Accumulation in the economy (SEEA EA Fig 13.1). The structure of the carbon stock account follows the structure of an asset account as described in the SEEA CF (Chapter 2).
3. There are close links between the data recorded in carbon stock accounts and the compilation of ecosystem accounts, for example in the measurement of ecosystem condition (e.g. using data on soil organic carbon) and the measurement of global climate regulation services using data on carbon sequestration and storage. In the implementation of SEEA EA the primary focus has been on measuring the carbon stock in the biosphere.
4. Accounting for carbon stocks is also recognised in the SEEA CF with section 5.8.5 describing in a few paragraphs "carbon accounts for timber resources" that describe the connection between measuring the stock of timber resources and measuring the stock of carbon in forests.
5. Comprehensive and coherent measurement of carbon stocks and changes in those stocks is of significant interest in many policy and analytical contexts, particularly in relation to climate change. More coherent measurement would support more robust derivation of indicators.
6. From an accounting perspective, while there are clear links between the measurement of carbon and the measurement of ecosystems, the measurement and recording of carbon stocks using an asset account structure is the same in accounting terms as accounting for individual environmental assets such as water and mineral resources as described in the SEEA Central Framework.
7. Thus, conceptually a carbon stock account may be considered a SEEA Central Framework type of account rather than a type of ecosystem account since the carbon stock itself is not an ecosystem asset (i.e. a space characterised by a distinct set of biotic and abiotic components). In addition, the potential scope of a carbon stock account extends beyond the carbon in

ecosystems and includes stocks of carbon in the economy, in fossil fuel resources and in other reservoirs that are beyond the scope of ecosystem accounting.

8. Nonetheless, there remains a clear rationale for maintaining the connection between carbon stock accounts and spatially explicit accounts for ecosystem extent and condition through consistent use of classifications and measurement frameworks (e.g. the ecosystem condition typology). Given the range of potential connections, a description of them is provided in Section 2.6.

1.2 Process for developing the Guidance Note (to be finalised ahead of global consultation)

9. This issue is being advanced through discussions in Task Team-D. A Scoping note was prepared and finalised in June 2025 which summarised the key aspects to be considered in the paper. The draft Guidance Note was subsequently discussed by Task Team-D and the SEEA Central Framework Technical Committee through late 2025 before finalisation for Global Consultation in February 2026. The drafting process also took into consideration the findings from a clarification note on the scope of environmental assets to be reflected in the updated SEEA Central Framework.

1.3 Structure

10. The remainder of this Guidance note covers: <<to be finalised, pending further discussion>>

Questions for the SEEA CF Technical Committee

11. This Guidance Note covers a number of significant conceptual issues and raises a range of questions concerning the direction for the update of the SEEA CF and the content of the updated SEEA CF. The views of the SEEA CF TC members are welcome on all of the questions raised below.

12. However, for the purposes of the discussion at the SEEA CF TC meeting in November 2025, members are asked to focus on those questions highlighted in **bold** below. Note that the core questions at this stage concern whether the carbon stock accounts should be included in the SEEA CF. Less priority has been given to question concerning the technical content concerning carbon stock accounts.

13. Concerning whether the carbon stock should be treated as an environmental asset and/or included in the SEEA CF:

    a. **Should the carbon stock be treated as an environmental asset in the SEEA CF? If so, what is the appropriate rationale? If not, what is the appropriate rationale?**

b. **Should the treatment of environmental assets be modified in the SEEA CF to accommodate different categories of assets in recognition of their different attributes but to ensure no double counting?**

c. **Should the monetary value of the carbon stock be considered in the SEEA CF or the SEEA EA? If so, what is the main motivation for undertaking this valuation?**

d. **Are there negative consequences of not including the carbon stock as an environmental asset?**

e. **Are there negative consequences of not including carbon stock accounts in the SEEA CF?**

14. Concerning the measurement scope and accounting treatments in the carbon stock account:

a. Do you agree to focus the accounting for carbon stocks on carbon stored in the biosphere, geosphere, the economy, the biological component of the oceans, and the atmosphere and the associated interactions between these reservoirs?

b. Do you have comments on the initial framing for measuring carbon in the economy, in particular concerning the treatment of carbon stored in cultivated biological resources?

c. What additional measurement scope issues should be considered?

d. Is the level of detail in the SEEA EA carbon stock account shown in Table 1 above, sufficient or are additional rows and/or columns required? If so, what additions should be made?

15. Concerning links to other SEEA accounts:

a. Do you agree with the direction and scope for further work on describing connections among SEEA accounts as outlined in section 2.5?

16. Concerning the link to UNFCCC reporting

a. What other considerations should be discussed about the link between SEEA carbon stock accounts and UNFCCC reporting?

b. Reconciling definitions and classification systems are some of the major issues for aligning the two systems. Should guidelines, and potentially bridge tables, be developed about how existing GHG inventory data can be used in carbon stock accounts and describing the additional data that are needed?

17. Concerning applications of carbon stock accounts:

a. Do you have other suggestions for potential applications and uses of carbon stock accounts that could be described?

2 Discussion of key issues

2.1 Introduction

18. The starting point for considering the description of carbon stock accounts in the SEEA CF is the content presented in the SEEA EA chapter 13 which has been included as an annex to this Guidance Note. That content provides a rationale and short description of carbon stock accounts with the basic structure of the account as shown in Table 1 below. Note that the carbon stock account in the SEEA EA is only described in physical terms. Aside from the discussion that has commenced in the preparation of the Guidance Note, no consideration has been given previously to the compilation of a carbon stock account in monetary terms.

Table 1: SEEA EA Carbon stock account structure

	Geocarbon					Biocarbon			Carbon in the economy			Carbon in the seas	Carbon in the atmosphere	Total
	Oil	Gas	Coal	Limestone and marl	Other	Terrestrial	Freshwaters and saline wetlands	Marine	Inventories	Fixed assets, cosumer durables	Waste	Total	Total	
Opening stock														
Additions to stock														
Natural expansion														
Managed expansion														
Discoveries														
Upwards reappraisals														
Reclassifications														
Imports														
Reductions in stock														
Natural contraction														
Managed contraction														
Downwards reappraisals														
Reclassifications														
Exports														
Net carbon balance														
Closing stock														

19. Discussion of the proposal to include a carbon stock account in the SEEA CF has drawn out a range of different opinions and considerations that are substantive in nature. They concern, inter alia, whether the carbon stock can be considered an environmental asset, whether it is more appropriate to describe the carbon stock account in the SEEA EA and whether it is appropriate to develop a carbon stock account in monetary terms.

20. There is general agreement that the compilation of a carbon stock account in physical terms is appropriate and none of the following discussion is intended to suggest that the advice in the

SEEA EA is inappropriate or incorrect. Thus, countries are encouraged to compile carbon stock accounts in physical terms. Thus, the discussion is focused on the rationale and alternatives for including carbon stock accounts in the SEEA CF. It is therefore relevant to note at the outset two alternatives for moving forward on this issue:

- First, not include carbon stock accounts in the SEEA CF and thus base their compilation on content in the SEEA EA
- Second, not include carbon stock accounts in the SEEA CF but examine options for updating and expanding the content in the SEEA EA in complementary guidance.

21. The remainder of the discussion here considers a perspective in which carbon stock accounts may be included in the SEEA CF. To the extent that the conclusion from discussing these issues is that no changes to the SEEA CF should be made then the alternatives just noted can be considered.

2.2 Carbon stocks and environmental assets

2.2.1 Discussion

22. An initial question in considering the proposed inclusion of the carbon stock account in the SEEA CF is whether the carbon stock should be treated as an environmental asset.

23. A separate clarification note on the interpretation of the definition and measurement scope of environmental assets as presented in the SEEA CF has been drafted. In relation to the treatment of the carbon stock, that clarification note highlights that SEEA CF paragraphs 2.19 and 2.100 both indicate that carbon itself should not be considered an individual environmental asset. Paragraph 2.19 notes that *"The coverage of individual assets does not extend to the individual elements that are embodied in the various natural and biological resources referred to above."* Paragraph 2.100 notes that *"Individual environmental assets comprise mineral and energy resources, land, soil resources, timber resources, aquatic resources, other biological resources and water resources. These assets are defined by their material content (e.g. the volume of timber or soil resources) without specific reference to their constituent elements (such as the carbon in timber and the nutrients in soil resources)".* Further, as noted above, although carbon stock accounts are described in the SEEA EA, there is no content there that suggests that carbon stocks, of themselves, are ecosystem assets.

24. Thus based on current SEEA CF and SEEA EA content one conclusion is to continue to consider that the carbon stock is not an environmental asset. In the drafting of this GN a range of additional points have been made both in favour of and against the treatment of the carbon stock as an environmental asset. These points are:

25. First, the extent to which the carbon stock can be considered to provide benefits to humanity, noting that the definition of environmental assets does not require benefits to be provide only that they "may provide" benefits. In the SEEA CF and the SEEA EA there are a range of benefits that are associated with carbon. Specific examples include the benefits from harvesting timber, from extracting oil resources and from global climate regulation services (comprising carbon

sequestration and retention by ecosystems). Thus, there is a case to be made that the carbon stock can provide benefits. It is noted however, that at present in all cases the benefits are not directly associated with carbon stocks but rather with an environmental asset that embodies the carbon stock such as timber resources, energy resources or ecosystem assets.

26. Notwithstanding the potential for the carbon stock to provide benefits, it has also been highlighted that this is likely not the case for the vast bulk of carbon stocks. Put differently, it is only specific carbon stocks that, at the margin, can be considered to provide benefits and a value of the total carbon stock is not an economically meaningful concept. In effect, some carbon stocks are valuable but others are not. Taking this point further it has also been noted that while many carbon stocks in the biosphere and geosphere will generally be considered to provide benefits to people and economic units, carbon stored in the atmosphere is considered to provide significant disbenefits. Indeed, this line of thinking leads to a possible framing of some carbon stocks being accounted for as liabilities.

27. While this marginal value and externality framing for considering whether carbon stocks should be treated as environmental assets, the same logic might also be applied for water. That is, there is implicit recognition that not all water is to be included in the scope of measuring water resources in physical terms – for example water embodied in biota, or soil water beyond agricultural areas. Further, in considering the valuation of water it is generally accepted that marginal valuation approaches should apply but this is not considered to provide a rationale for necessarily limiting the scope of water resources asset accounts in physical terms. It might also be considered that in some circumstances water can be a liability (e.g. in relation to floods).

28. Second, the inclusion of carbon stock as an environmental asset could imply a double counting in an aggregate scope of either individual environmental assets or ecosystem assets. At present in the SEEA CF and SEEA EA, the physical stock and associated benefits of the carbon stock are not separately accounted for in the SEEA. Thus, in an overall balance sheet context this appears appropriate, i.e. double counting would be implied if the benefits of the carbon stock were separately calculated and added to the benefits of environmental assets.

29. However, it is also the case that there is an overlap between individual environmental assets and ecosystem assets – for example between timber resources and forest ecosystems. To accommodate carbon stock as an environmental asset one option would be to create a third category of environmental assets comprising individual elements. A separate accounting for them would be possible provided any physical stock or monetary values were added to environmental assets within the other two categories.

30. Third, there are currently some elemental compounds which are treated as environmental assets in the SEEA CF. Examples include water which is treated as water resources and individual minerals (e.g. copper) which are treated as types of mineral and energy resources. In these cases, the interpretation of the SEEA CF at present appears to be that individual elements and substances can be treated as environmental assets provided that they are not, at the same time, also included in the measurement of another environmental asset.

31. Overall, there are a range of conceptual and practical accounting issues which suggest that the treatment of the carbon stock as an environmental asset in physical terms is not clear cut. A conclusion is needed on the rationale for a treatment.

2.3 The monetary value of carbon stocks

2.3.1 Discussion

32. Beyond the question of whether carbon stocks can be considered an environmental asset in physical terms, the related question is whether the cabon stock can be considered to have value in monetary terms. In the discussion above, the link to value concerned whether there was a benefit flow that might be associated with the carbon stock that would provide a rationale for satisfying the definition of an environmental asset in physical terms. Here, the focus is on whether there is a case for compiling carbon stock accounts in monetary terms. Again a range of views have been expressed.

33. First, it may be relevant to consider that some carbon stocks have value in and of themselves if they are the focus of some types of carbon markets. For example, where carbon offset buyers are willing to pay owners of carbon stocks cash or equivalent (e.g. debt swaps) to keep those carbon stocks in place, there are potentially meaningful instances where carbon stocks may be considered economic assets. The potential to treat carbon stocks as economic assets, i.e. satisfying the definition of an asset in the SNA, requires further consideration and discussion with the national accounts community.

34. Thus, in the update of the SEEA CF it may be beneficial to incorporate a structure that will support these future policy needs, even if the exact location and type of carbon stocks relevant are not known at present. In this way the SEEA CF is forward-looking to support future policy needs. Demonstrating the connection between the carbon stock and the wider balance sheet and the associated connection to the climate system may be very useful.

35. At the same time, it is relevant to highlight that further examination of this issue will not identify that all carbon stocks have value, only specific stocks in specific circumstances. In effect, to those carbon stocks that contribute to avoided emissions. Whether this is sufficient to justify compilation of a carbon stock account in monetary terms requires further discussion.

36. Second, the valuation of carbon stocks might be considered more broadly. Building on the suggestion above that carbon stocks might be treated as a third category of environmental assets (separate but overlapping with individual environmental assets and ecosystem assets), it would be possible to envisage placing a value on a range of carbon stocks for reasons other than avoided emissions. For example, fossil fuel resources, diamonds, timber resources, and various ecosystem services dependent on biotic components of the ecosystem might have some, if not all, of their value attributed to the carbon stock embodied in them. In some of these cases a link might be made to economic owners and beneficiaries consistent with the valuation approach in the SEEA CF.However, in other cases the valuation scope is more aligned with that applied in the SEEA EA for ecosystem services including global climate regulation

services. While some of these services may be monetised through carbon markets, this is a relatively small share of the total flow of services provided by ecosystems.

37. Overall, it appears possible to identify some values associated with the carbon stock that could be considered to fall within the valuation scope generally applied in the SEEA CF. Certainly, further investigation is required of the value of carbon stocks that are directly related to carbon markets. However, it is also apparent that any estimated value will relate to a relatively small share of the carbon stock in physical terms. This may suggest that compilation of a carbon stock account in monetary terms is not appropriate.

2.4 Including carbon stock accounts in the SEEA CF

2.4.1 Discussion

38. If it is determined that the carbon stock is an environmental asset, then the inclusion of carbon stock accounts in the SEEA CF, at least in physical terms, seems appropriate. However, if the carbon stock is not considered an environmental asset then the inclusion of carbon stock accounts in physical or monetary terms needs to be separately considered. The following points have emerged in considering this issue.

39. First, in accounting terms it is certainly possible to compile accounts in physical terms to record the opening and closing stock of carbon and changes in that stock following the standard asset account structure as described in the SEEA CF Chapter 2. This has been demonstrated in the SEEA EA. From an accounting structure perspective there is no obvious restriction in including carbon stock accounts in the SEEA CF.

40. Second, since carbon stock accounts are already described in the SEEA EA, it may be concluded that this provides sufficient content to support countries in compiling these accounts. However, it is noted that

    a) The content concerning the carbon stock account is not considered an international statistical standard but rather as an application and extension. Thus, inclusion of the content in the updated SEEA CF may mean that the carbon stock account is part of an international statistical standard (noting that outcomes from the update process cannot be assumed).

    b) As discussed in the following sections, the content describing carbon stock accounts in the SEEA EA may be improved as part of the SEEA CF update process which may be considered appropriate.

    c) There is the opportunity in the SEEA CF update process to incorporate content on the measurement of carbon stocks beyond the biosphere, in particular in the economy, and to describe flows between different reservoirs. This wider measurement scope is not a focus of the discussion in the SEEA EA.

41. Third, inclusion of the carbon stock account in the SEEA CF and further development of the content through the update process creates an opportunity to highlight the potential of carbon

stock accounting in physical terms and to move measurement beyond the more limited scope offered through UNFCCC reporting.

42. Fourth, there are some substantial measurement challenges in practice and, depending on the measurement scope that is determined, it may be difficult to establish sufficient robustness in measurement for inclusion in the SEEA CF. This may be particularly the case for accounts in monetary terms. More generally, it may be considered that there are more important measurement challenges to be considered in a SEEA CF context.

43. Fifth, the carbon stock account in physical terms is closely connected to a range of other SEEA CF accounts (see discussion below) and the inclusion of this account in the SEEA CF provides a more complete accounting structure across the SEEA CF and encourages increased coherence in measurement, for example in relation to air emission accounts and energy accounts.

44. Overall, the case for including carbon stock accounts in physical and potentially monetary terms is not clear cut.

2.4.2 Questions

45. The following questions are posed to support discussion of the issues:

a. Should the carbon stock be treated as an environmental asset in the SEEA CF? If so, what is the appropriate rationale? If not, what is the appropriate rationale?

b. Should the treatment of environmental assets be modified in the SEEA CF to accommodate different categories of assets in recognition of their different attributes but to ensure no double counting?

c. Should the monetary value of the carbon stock be considered in the SEEA CF or the SEEA EA? If so, what is the main motivation for undertaking this valuation?

d. Are there negative consequences of not treating the carbon stock as an environmental asset?

e. Are there negative consequences of not including carbon stock accounts in the SEEA CF?

2.5 Measurement boundaries and accounting treatments for carbon stock accounts

2.5.1 IntroductionMeasurement boundary and accounting treatment issues

46. As part of determining whether the carbon stock accounts should be included in the updated SEEA CF, the following conceptual and measurement improvements to the content currently in the SEEA EA are considered the primary areas of focus. They are presented in relation to four primary questions. Note that these issues concern accounting for carbon stocks in physical terms only. Additional issues concerning accounting in monetary terms will need to be

incorporated pending a conclusion on whether a carbon stock account in monetary terms should be included in the updated SEEA CF.

a. Should all five primary carbon reservoirs be within scope of a carbon stock account – i.e. biosphere, geosphere, economy, atmosphere and oceans ?

   - Conceptually, it is proposed that the scope of the carbon stock account should include all carbon reservoirs maintaining the scope of the accounts described in the SEEA EA.
   - The carbon stock account presented in Table 1 is from the SEEA EA and uses column headings of geocarbon, biocarbon, seas. It is proposed to update these labels to refer to the geosphere, biosphere and oceans. Further, the oceans should be disaggregated into organic and inorganic carbon, where the organic carbon would include the biocarbon in the marine realm.
   - The measurement of carbon stocks for the biosphere, geosphere and the economy is considered possible from a statistical perspective building on a range of information and data that are generally available. At the same time, further discussion is needed on the precise scope of carbon stocks that is measureable in practice (e.g. concerning the measurement scope for carbon in the geosphere) and whether, for some reservoirs, the changes in stocks are considered sufficiently meaningful given expected uncertainties in measurement.
   - However, from a practical and applications perspective it is proposed to limit the measurement of carbon stocks in the ocean to a focus on biocarbon, i.e. the carbon stocks in marine and coastal vegetation whose measurement is considered feasible and are useful to include.
   - The measurement of carbon stocks in the atmosphere is considered more challenging particularly in terms of allocation to countries. Approaches to allocation of stocks to countries have been developed using an aggregation of past emissions (see Statistics Netherlands, 2017) and assessing damages suffered due to climate change. The rationale and feasibility of implementing these approaches should be examined for potential application in a SEEA context. This is of high relevance since it is the increase in the stock of carbon in the atmosphere that is at the heart of climate change.

b. Can the boundaries between the different carbon reservoirs be better delineated? (building on content in SEEA EA Annex 13.2)

   - SEEA EA Annex 13.2 provides a good starting point but further detail is needed on describing the scope of carbon in the economy and carbon in the biosphere, in particular concerning the boundary for cultivated biological resources (e.g. plantation timber) and in relation to soil resources.

- The initial proposal is for the economy to be defined in relation to the production boundary of the SNA such that all carbon stored in cultivated biological resources is considered within the economy and all carbon stored in non-produced environmental assets (including soil and sub-soil mineral and energy resources) is considered to be in the biosphere or geosphere as appropriate.
- In cases where there has been extraction or harvest of environmental assets, the carbon embodied in the products created as a result of this activity should be treated as carbon in the economy.
- Further discussion will be needed on the treatment of carbon stored as a result of carbon capture and storage where the location of the storage will likely be an important consideration.
- The following section provides some further discussion on the measurement of carbon in the economy. It is also noted that the discussion on these issues will need to align with the related discussion under issue B3 on Carbon flows.

c. What scope of carbon in the biosphere should be applied in practice, especially with respect to carbon stored in peatlands and related ecosystem types?

- The measurement boundary should include all ecosystems and land tenures within a country. In which case, the boundary should not be limited by a focus on areas of current human activities or on areas with specific degrees of management. A national scope provides the starting point for an exhaustive measurement of the carbon stock.
- Establishing measurement boundaries in terms of depth for peatlands and soil are a difficult compromise between comprehensiveness and practicality but are important in terms of providing comparable data over time and across countries. In concept, the depth would be extended to encompass all carbon however in practice depths such as 2m, 1m or 30cm are likely to be applied depending on data sources.

d. What distinctions should be made between different types of addition and reductions in stock (as described in SEEA EA Annex 13.2 and copied below)?

- Discussion of this question will need to consider the links with other accounts in the SEEA CF and SEEA EA such that the structures and levels of granularity are coherent and meet the requirements for reporting and analysis – for example in relation to recording LULUCF emissions and carbon capture and storage.
- In the first instance it will be relevant to ensure that the reductions in stock from each reservoir can be distinguished between those due to human activity and those due to natural factors. This will tend to focus on reductions in stock from the geosphere, biosphere and the economy but will also concern

removals of carbon from the atmosphere by both the biosphere and through carbon capture and storage. A close coherence will be needed in measuring these reductions with the measurement and recording of carbon flows and the reporting of GHG emissions, including LULUCF emissions.

- Further, as a general principle, the ambition should be to record all flows – both additions and reductions – among all of the reservoirs, i.e. recording changes in gross terms (noting that it will be relevant to focus on annual flows and set aside daily flows such as those relating to photosynthesis). A gross recording approach allows for more detailed understanding of the connections between the different stocks and supports identifying specific sources and sinks of carbon in an integrated way and attribution of changes.

2.5.2 Measuring carbon in the economy – initial considerations

47. Building on the content in the previous section, this section considers the feasibility of quantifying the amount of carbon embodied in the stock of assets that constitute the economy, and how such stocks might be linked to the corresponding inflows and outflows. Given the production boundaries established in the 2025 SNA, the question arises as to the extent to which these boundaries can be aligned with the carbon stock boundaries defined in the SEEA EA.

48. Note that considerations relating to the whole-of-life carbon emissions of economic assets are not discussed here. These would typically include emissions generated during the construction phase, prior to the asset's use, as well as those arising from its operational phase (e.g. heating, cooling, lighting).

49. The inclusion of carbon embodied in physical produced non-financial assets (excluding natural resources) is conceptually straightforward. However, the treatment of carbon embodied in environmental assets presents greater complexity. In particular, it is necessary to examine the extent to which carbon stored in biological and geological stocks should be included as part of carbon stored in the economy.

50. The SEEA EA not only supports the inclusion of carbon embodied in anthropogenic[1] products, but also suggests that certain biological carbon stocks may be relevant. For instance, raw materials that may be extracted from various ecosystem types—such as biomass fuel from natural or agricultural ecosystems, or meat from agricultural or semi-natural ecosystems—as well as fossil fuels extracted from geocarbon reservoirs, could fall within scope.[2]

[1] SEEA_EA: "Accumulations in the economy, which are the stocks of carbon in anthropogenic products, are further disaggregated into the following SNA components: fixed assets (e.g., concrete in buildings, bitumen in roads, livestock); inventories (e.g., petroleum products in storage, excluding those included in agricultural ecosystems); consumer durables (e.g., wood and plastic products); and waste (Paragraph A13.20).

[2] SEEA-EA: "The level at which geocarbon and biocarbon stock changes can be linked to the economy will determine the policy usefulness of the carbon stock account. This is particularly relevant in cases where raw materials can be extracted from different

51. That said, the inclusion of carbon sequestered by forest land remains more contentious. A frequently debated issue among environmental experts is the distinction between managed and unmanaged land. While the SEEA CF employs these categories in the context of land cover accounts, the SEEA EA seems to take a more refined approach by referring to managed and unmanaged accumulations and contractions, thereby focusing on flows and their drivers rather than stocks, and not referring to the land area as a whole being managed or unmanaged.

52. Table 2 below outlines a possible correspondence between the accounting frameworks. In contrast to the SNA asset boundary definition, this analysis also considers consumer durable goods, while inventories, although explicitly referenced in the SEEA EA, are here implicitly included within non-financial produced assets.

53. It is highlighted that in Table 2 the boundary line between the economy and the biosphere is drawn in an alternative location compared to the discussion in the previous section. In Table 2, carbon stored in cultivated biological resources is included in the biosphere whereas in the discussion above it is included in the economy. The treatment in the table avoids the results being affected by the distinction between cultivated and non-cultivated natural resources and hence may be a useful approach. The choice of boundary does not affect measurement directly but will influence the appropriate interpretation of different indicators and analysis undertaken using these data.

2.5.3 Questions

54. The following questions are posed to support a discussion of the issues introduced in the previous two sections:

    a. Do you agree to focus the accounting for carbon stocks on carbon stored in the biosphere, geosphere, the economy, the biological component of the oceans, and the atmosphere and the associated interactions between these reservoirs?

    b. Do you have comments on the initial framing for measuring carbon in the economy, in particular concerning the treatment of carbon stored in cultivated biological resources?

    c. What additional measurement scope issues should be considered?

    d. Is the level of detail in the SEEA EA carbon stock account shown in Table 1 above, sufficient or are additional rows and/or columns required? If so, what additions should be made?

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ecosystem types (e.g., biomass fuel from natural ecosystems or agricultural ecosystems; meat from agricultural ecosystems or semi-natural ecosystems) or from geocarbon reservoirs with different carbon contents and emissions profiles (Paragraph A13.21).
A13.23 The presentation of the row entries in the account follows the basic form of the asset account in the SEEA Central Framework; the entries being opening stock, additions, reductions and closing stock. Additions to and reductions in stock have been split between managed and natural expansion and contraction. Additional rows for imports and exports have been included, thus making the table a stock account, as distinct from an asset account.

Table 2
Main Components:

		SNA	SEEA-CF 2028	SEEA-EA
Consumption goods	Consumer durables		carbon in anthropogenic products	carbon accumulated in the economy
Economic Capital	Produced non-financial assets (excluding natural resources)	Assets in the integrated framework of national accounts.		
	Non-produced non-financial assets (excluding natural resources)			
	Financial assets and liabilities			
Natural Capital	Natural resources: Land Soil resources Mineral and energy resources (renewable and non-renewable) Biological resources Water resources Other natural resources		carbon in natural resources	geocarbon, biocarbon
	Ecosystem assets		Ecosystem assets	Carbon in the oceans (inorganic only) and in the atmosphere.

2.6 Connections to other SEEA accounts

2.6.1 Discussion

55. There are a number of connections between carbon stock accounts and other accounts in the SEEA CF. The following connections should be described to support integration across the accounting system. Relevant SEEA CF accounts include:

    a. Air emissions accounts for GHG emissions to ensure coherence between stocks and flows of carbon. The alignment required will relate to flows of carbon between the economy and the atmosphere. Specific issues will concern the consistent treatment of flows related to LULUCF emissions, carbon capture and storage and biological resources.

    b. Energy flow accounts to ensure coherence between the supply and use of fossil fuels and stocks and flows of carbon. The alignment here will relate to changes in stocks of fossil fuel resources in the geosphere and inventories of petroleum products, gas and coal in the economy.

    c. Mineral and energy resources accounts to ensure coherence between the stocks and changes in stock of fossil fuels and stocks and flows of carbon.

    d. Material flow accounts and the potential to record inputs from the environment in the case of cultivated biological resources in terms of specific elements. The primary focus of alignment here is the delineation of the boundary between the biosphere and the economy in relation to cultivated biological resources.

    e. Timber resource accounts and Forest land accounts to ensure coherence between the stocks and changes in stock of timber resources, the area of forests and stocks and flows of carbon. The primary focus of alignment here is the delineation of the boundary between the biosphere and the economy in relation to cultivated biological resources but also of relevance will be alignment with estimates of LULUCF emissions.

    f. Soil resource accounts to ensure coherence between measures of the quality of soil resources and stocks of soil organic carbon.

56. In addition, there are close links between carbon stock accounts and ecosystem accounts. Knowing this, it would be useful to describe specific ways in which carbon stock accounts as described in the SEEA CF can be linked to the SEEA EA extent and condition accounts and ecosystem services accounts, considering relevant principles such as classifications, spatial granularity and maintaining the spatial context. In this regard, the SEEA CF and the SEEA EA should be considered a single integrated framework and this particular aspect of the connection may be considered further in SEEA CF update issue A1 on the links between the SEEA CF and the SEEA EA.

57. More generally, it is relevant to consider the role of the SEEA in describing an integrated and comprehensive framework for the measurement of the relationship between the environment and the economy. While it is thus important that each account within the overall framing have a purpose and meaning in its own right, there is also a significant benefit that emerges from describing a more complete system. From this perspective, and recognizing that carbon is a fundamental element underpinning our society and economy, a carbon stock account provides an organizing framework for connecting many aspects of the environment-economy relationship.

58. In this wider setting of the whole SEEA system, it is of far less significance as to whether carbon stock accounts are considered part of the SEEA CF or the SEEA EA. Since there are clear connections to accounts across both documents, what is critical is that the integrating role of carbon stock accounts is effectively described and explained. This connection is particularly evident in relation to carbon in the connection between the supply and use table for air emissions and the carbon stock accounts for carbon in the economy and the atmosphere. Building the connections between these accounts creates a rich information system for decision makers and analysts.

59. Further, it is noted that the comprehensive framework of the SEEA facilitates the integration of data from multiple sources. In relation to carbon stocks, it is not expected that there is an existing single data source that will provide estimates of all carbon stocks and changes in stocks across all carbon reservoirs. Thus, the SEEA framework provides the basis for identifying and confronting relevant data sets to compile an overall picture of carbon stocks and the changes in those stocks that are connected to economic and other human activity.

60. The following question is posed to support a discussion of the issues:

    a. Do you agree with the direction and scope for further work on connections among SEEA accounts as outlined in this section?

2.7 Connections to UNFCCC reporting

2.7.1 Discussion

61. The prime motivation for compiling carbon stock accounts is to support the analysis and discussion of climate change and related policies. In this context, a close connection exists to the motivations for reporting to the UNFCCC and in particular the recording of LULUCF net emissions. An important consideration is that the motivation for UNFCCC reporting is understanding the additions of carbon to the atmosphere. In following this motivation there is thus no specific focus on the measurement of carbon in the geosphere or carbon in the economy and while there is some interest in carbon in the environment there is no specific focus on stocks of carbon from a reporting perspective.

62. Consequently, it is to be expected that there are differences between the UNFCCC/IPCC based reporting for carbon and the SEEA carbon stock account that are likely to be materially relevant for climate change policy. At the same time, it is possible to describe ways of using IPCC based

data to support the compilation of SEEA carbon stock accounts. The differences and linkages between the SEEA carbon stock accounts and UNFCCC reporting are detailed in this section.

63. While national GHG inventory data can be used to compile SEEA accounts, fully compiled SEEA carbon stock accounts are more comprehensive and hence can be valuable for enhancing GHG inventory reporting and for informing climate policies. The following points are noted:

    a. Differences in measurement scope between SEEA and IPCC data include stocks, gross additions and reductions, all land areas (not differentiated by land use).

    b. Data collected for national GHG inventories may include information useful for compiling SEEA accounts that is not reported (and hence not obvious) in the inventories. For example, data on carbon stocks, gross additions and reductions may be collected but not reported. Information about land areas not included in the inventory is often available in government agencies.

    c. Classifying carbon stocks in the environment by ecosystem type and condition class allows assessment of their longevity and stability, and hence value as carbon reservoirs. The capacity of the land sector to store carbon as a benefit for the climate is dependent on many other ecosystem processes that are best represented as the integration of environmental and ecosystem accounts. This information about the dependencies of carbon storage within ecosystems is important to identify options, evaluate and prioritise effective and efficient mitigation activities.

    d. Integrating carbon stock accounts with accounts for environmental assets, physical flows and ecosystem services provides a more holistic approach to managing the land sector than GHG inventories alone.

    e. For example, the use of a standardised reference level for ecosystem condition accounting in the SEEA EA that is defined in terms of ecosystem integrity is an advantage of the accounting framework as a whole.

    f. The mitigation benefits of the land sector arise through the retention of carbon stocks in reservoirs and hence the avoided release of carbon to the atmosphere. Hence, reporting on stocks and stock changes in asset accounts provides more comprehensive information than reporting of flows in GHG inventories.

    g. The comprehensive approach to carbon stock accounting that links carbon stocks to other environmental assets and services under the SEEA framework will facilitate consistency in policy development across the Rio Conventions of the UNFCCC, CBD, UNCCD and Sustainable Development Goals.

64. Some specific considerations on the link to UNFCCC reporting concern the link to measuring carbon in the economy. While the Intergovernmental Panel on Climate Change (IPCC) does not explicitly define or systematically account for carbon stocks embodied in economic goods—such as manufactured products, buildings, or consumer goods—within its core greenhouse gas inventory guidelines, two related concepts are of particular relevance: harvested wood products (HWP) and embodied emissions in materials.

65. Concerning harvested wood products, under standard IPCC accounting practices, it is generally assumed that all harvested biomass is oxidised (i.e., emitted as CO_2) in the accounting period of harvest. However, the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Good Practice Guidance for Land Use, Land-Use Change and Forestry (LULUCF) allow for the inclusion of carbon stored in Harvested Wood Products—such as timber used in construction or furniture—provided that the stock is increasing. Key characteristics of HWP accounting include: optional inclusion in national inventories, subject to methodological constraints and HWP being assigned longevities and thus treated as a form of delayed emission, rather than permanent carbon storage. HWP is a major component of the modelling in national inventories. Products differ in their half-lives and decomposition rates, in the same way as pools of carbon in the biosphere.

66. Concerning embodied emissions in buildings and infrastructure, the concept of embodied emissions is addressed in the IPCC Sixth Assessment Report (AR6), particularly in Chapter 9, which focuses on the building sector (IPCC AR6 WGIII Chapter 9). Embodied emissions refer to the greenhouse gas emissions associated with the production of materials—such as cement, steel, and glass—used in the construction of buildings and infrastructure. These emissions are not treated as carbon stocks in IPCC accounting; and are considered emission sources, typically attributed to the industrial and energy sectors.

67. Overall, developing SEEA carbon stock accounts with as much detail as possible is extremely valuable for informing UNFCCC reporting and climate policy. SEEA carbon stock accounts that report stocks and gross additions and reductions is important information that should be used for climate policy and land management. Hence, for example, SEEA carbon stock accounts should include all the components of LULUCF.

2.7.2 Questions

68. The following questions are posed to support a discussion of the issues:

   a. What other considerations should be discussed about the link between SEEA carbon stock accounts and UNFCCC reporting?

   b. Reconciling definitions and classification systems are some of the major issues for aligning the two systems. Should guidelines, and potentially bridge tables, be developed about how existing GHG inventory data can be used in carbon stock accounts and describing the additional data that are needed?

2.8 Applications and uses of carbon stock accounts

2.8.1 Discussion

69. To design a generic structure of carbon stock accounts it is important to consider the potential uses and applications of the accounts, for example in terms of industry detail and detail within each type of reservoir. Starting from the design of the carbon stock account presented in the

SEEA EA and in light of the potential extensions considered above, this section describes potential uses and applications and proposes alternative structures for the carbon stock account.

70. Possible applications and uses of carbon stock accounts include:

a. Applications in the context of carbon markets including links to carbon credits, emission trading schemes and related mechanisms, company reporting on progress towards climate targets and climate-related financial disclosures.

b. The potential to design a carbon stock change matrix showing the movements across different carbon reservoirs over time and thus supporting targeted analysis of the drivers of changes in carbon stocks across the biosphere, geosphere, economy and atmosphere. This matrix could be developed following the principles of the land cover change matrix presented in the SEEA CF and SEEA EA.

c. The potential to map complete carbon "supply chains" for specific products or activities. For, example the production of concrete will use carbon stored in limestone (geosphere) and fossil fuels (geosphere) to produce concrete which is stored in the economy while generating emissions to the atmosphere both during production and at end of life. This type of accounting is used in the corporate sector to report on Scope 3 emissions and is increasingly being used for reporting on Taskforce on Climate-related Financial Disclosures.

d. The potential to map flows of embodied carbon in international trade and make the connection to changes in the carbon stocks in the geosphere and biosphere at the commencement of those trade flows.

e. Supporting the development and implementation of national carbon budgets. Consistent recording of the stocks of carbon in all reservoirs provides the underpinning information to understand the potential for the release of carbon and hence support modelling of changes in carbon stocks under alternative policy options and the implications of limiting the releases of carbon.

f. Tracking the effects of the energy transition in terms of implications on the stocks of carbon in the geosphere, economy and atmosphere.

g. Using spatially explicit data on carbon stocks in the biosphere and their stability as indicated by the ecosystem condition account to prioritise locations and land management activities for implementing nature-based solutions and emissions reductions.

h. Supporting the compilation of SEEA accounts. As noted above there are many connections between carbon stock accounts and other SEEA accounts. The compilation of carbon stocks accounts can be a core data output that underpins many other accounts given its comprehensive and consistent framework. Examples include air emission accounts, ecosystem condition accounts and ecosystem services accounts.

71. The following question is posed to support a discussion of the issues:

   a. Do you have other suggestions for potential applications and uses of carbon stock accounts that could be described?

3 Recommendations (to be developed)

Notes to authors

- In this section, propose recommendations to address the issue (based on the options described under section 3). As appropriate, note connections and potential implications for other issues being considered in the update process.
- Note that final recommendations on conceptual treatments will not be determined until after the Global Consultation process so the development of content in this section is likely to be more in the form of proposals for consideration, but this will vary from issue to issue.
- Also, list the sections/paragraphs of the SEEA CF that need to change or where additional content is required
- Finally, where possible and appropriate provide proposed text for inclusion in the revised SEEA CF (This content is not required for the initial drafts and, depending on the issue, it may not be possible to propose text ahead of Global Consultation, i.e. until there is more clarity on the option to be incorporated.)

4 Other considerations in advancing the issue (to be developed)

Notes to authors

- If relevant, propose **indicators** (and their derivation methods) that could be derived for this issue to support reporting and analysis
- Document **key terms and definitions** for inclusion in the SEEA CF Glossary
- Describe the existing **compilation guidance** and document what additional compilation guidance might need to be updated or developed (do **not** provide the guidance itself, that is not for inclusion in the SEEA CF)
- If relevant, describe **options for testing** the possible approaches. For some issues – e.g. for pressure accounts and sustainable finance, where the development of data and methods is less advanced, it may be useful for some countries to investigate and test the options proposed in section 3 to support determining the appropriate recommendations.
- Document any issues that remain unresolved as a result of the investigation or issues that have emerged as a result of the work that should be placed on the **research agenda** of the SEEA and potentially in relation to other statistical standards (e.g. SNA, BPM, etc.)
- For issues that are also being considered in the **GFS and COFOG revision processes**, describe the connections and potential differences in proposed treatments

Annex 1: SEEA Ecosystem Accounting Carbon stock account content

13.4 Accounting for climate change

13.4.1 Introduction

13.49 Climate change is one of the major global challenges of our time. Ecosystem accounting can provide data to understand the key role ecosystems play in greenhouse gas (GHG) cycling on global, national and regional scales that underpin the carbon concentration in the atmosphere. In addition, data from the ecosystem accounts can help to understand the impact that climate change is having on ecosystems and biodiversity. This connection among ecosystems, climate change and biodiversity and the need to consider them jointly is recognised in the UNFCCC CoP25 decision that "underlined the essential contribution of nature to addressing climate change and its impacts and the need to address biodiversity loss and climate change in an integrated manner"[3] SEEA as an integrated statistical framework thus can play an important role in supporting international and national policy discussions related to climate change. Furthermore, it can provide the underlying data that link climate change to other environmental topics – e.g., biodiversity, circular economy.

13.50 The SEEA EA accounts in combination with the accounts from the SEEA Central Framework and SNA can support various aspects of climate change policy – e.g., carbon mitigation and adaptation policies, carbon markets and financing mechanisms, carbon stock assessment and management, linking air emissions and economic activity, recording and modelling climate change outcomes on ecosystems, ecosystem services and economic activity, sector based assessments (e.g., agriculture), ecosystem focused planning (e.g., peatlands), inform on the co-benefits of carbon projects and policies, and the impacts of mitigation responses.

13.51 Thematic accounting for climate change complements existing measurement approaches described in the IPCC Guidelines in two ways. First, carbon emissions from terrestrial ecosystems result from *two processes*: human activities (management) and environmental change. The IPCC guidelines for GHG accounting have been developed to account for net emissions due to human activities. The SEEA EA are comprehensive (e.g., in its carbon account) and include both managed and unmanaged lands (its wide asset boundary ensures all land is in scope). Second, the SEEA allows making the connection with economic activities.

13.52 This section introduces how accounting can provide information to support decision making about climate change. Three aspects are considered: the potential of data from the ecosystem accounts to inform decision making; accounting for stocks and changes in stocks of carbon; and other accounting connections and indicators. As for thematic accounting generally, the aim in this section is to introduce a range of connections to provide insight into the potential of accounting approaches.

[3] UNFCCC, Conference of the Parties, Twenty-fifth session, Madrid, 2–13 December 2019, FCCC/CP/2019/L.10. https://unfccc.int/sites/default/files/resource/cp2019__L10E_adv.pdf

13.4.2 Applying the SEEA EA to inform climate policies

13.53 Several of the ecosystem accounts provide data to support monitoring and analysis of climate change policies. In general, this connection emerges because of the impact that climate change has on the extent and condition of ecosystem assets and flows of ecosystem services. That is, the ecosystem accounts are a framework for recording a range of climate change effects on the environment and showing the links to economic and other human activity. By using a common framework for recording these effects, it is straightforward to compare the effectiveness of different policies aimed at mitigating or adapting to climate change.

13.54 The extent account shows the managed and unmanaged conversions in ecosystem types that directly underpin changes in carbon uptake and release from ecosystems. Data from extent accounts can therefore be linked to the assessment of GHG emissions arising from land use, land use change and forestry (LULUCF) as used in IPCC measurements. The link between LULUCF and accounting is described in detail in the SEEA Agriculture, Forestry and Fisheries.

13.55 The condition account contains ecosystem characteristics and indicators that are highly relevant for climate change. Relevant physical state characteristics that that relate to carbon stored in ecosystems include soil organic carbon, and dry matter productivity. Carbon stock indicators for biomass provide a direct link to the carbon stock account described below. Condition indicators should also capture the local impacts of climate change on ecosystem condition, for example the effects on local temperatures and rainfall patterns may be relevant in assessing condition in some contexts. Note however, that ecosystem accounts do not incorporate direct measurement of climate per se, for example in terms of atmospheric and ocean concentrations of GHG or in terms of comprehensive data on temperatures and rainfall.

13.56 The reference list for selected ecosystem services (Table 6.2) includes several ecosystem services that are particularly relevant for climate change policies. Global climate regulation services are the ecosystem contributions to the regulation of the concentrations of gases in the atmosphere that impact on global climate, primarily through the sequestration and retention of carbon in ecosystems. The physical and monetary ecosystem service flow accounts (chapters 6, 7 and 9) show what ecosystem types play an important role in carbon sequestration and retention and how these change over time. Physical data on carbon retention and sequestration by ecosystem type are embodied in the carbon stock account described below.

13.57 Furthermore, there are several regulating ecosystem services that mitigate the effects of climate change. Local climate regulation services are the ecosystem contributions to the regulation of ambient atmospheric conditions. Examples include the evaporative cooling provided by urban trees and the contribution of trees in providing shade for livestock. Rainfall pattern regulation services are the ecosystem contributions of vegetation at the sub-continental scale, in particular forests, in maintaining rainfall patterns through evapotranspiration. Flood mitigation services, including both tidal surge and river flood mitigation, are the ecosystem contributions that mitigate the impacts of floods on local communities. Storm mitigation services are the ecosystem contributions of vegetation, especially linear elements in the landscape, in mitigating the impacts of wind, sand and other storms (other than water related events) on local communities. The accounts indicate what ecosystem types are the main contributors to reducing the effects of climate change, but also who the main beneficiaries are of these ecosystem services.

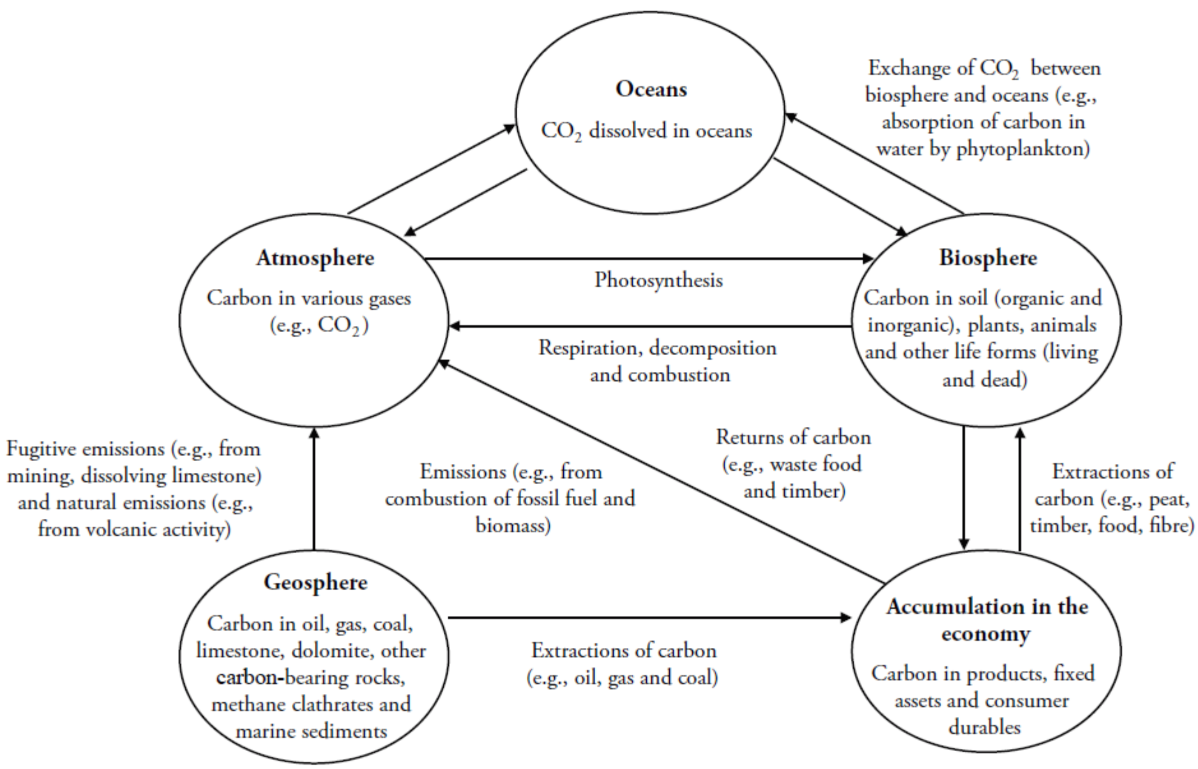
13.58 Finally, flows of several ecosystem services, including provisioning and cultural services, will be impacted by climate change e.g., water supply, biomass provision, recreation services etc, although isolating the precise contribution of climate change to the flows of ecosystem services is not the ambition in the accounts.

13.4.3 Accounting for carbon

13.59 Carbon has a central place in ecosystem and other environmental processes and hence accounting for carbon stocks and transfers between them is an important aspect of environmental-economic accounting. The carbon stock account provides a comprehensive coverage of all relevant carbon stocks and changes in stocks across all stores of carbon at a national or sub national level covering both managed and unmanaged lands.

13.60 The fact that carbon plays an extensive role in the environment and the economy calls for a comprehensive approach to its measurement. Accounting for carbon must therefore consider stocks and changes in stocks of carbon of the geosphere, the biosphere, the atmosphere, oceans and the economy. Figure 0.1 presents the main components of the carbon cycle. It is these stocks and flows that provide the context for carbon accounting. The same accounting principles can also be applied to account for other GHG including NO_x.

Figure 0.1: The main components of the carbon cycle



13.61 The structure of a carbon stock account is presented in Table 0.1. It provides a complete and ecologically grounded articulation of carbon accounting based on the carbon cycle and, in particular, the differences in the nature of particular carbon reservoirs. Opening and closing stocks of carbon are recorded, with the various changes between the beginning and end of the accounting period recorded as either additions to, or reductions in, the stock. A more detailed description of the carbon account is provided in Annex 13.2.

13.62 Carbon stocks are disaggregated into: geocarbon (carbon stored in the geosphere) and biocarbon (carbon stored in the biosphere, in living and dead biomass), carbon in the oceans (carbon dissolved in seawater, carbon in sediments is part of biocarbon or geocarbon), carbon in the atmosphere and carbon accumulated in the economy.

13.63 The row entries in the account follow the basic form of the asset account in the SEEA Central Framework: opening stock, additions, reductions and closing stock. Additions to and reductions in stock have been split between managed and unmanaged expansion and contraction. The net carbon balance equals addition to stock minus reductions in stock.

13.64 All values in the carbon stock account should be in equivalent carbon weights (e.g., tonne carbon). Accordingly, methane (CH_4) and carbon dioxide (CO_2) emissions should be expressed in ton carbon, not in the actual mass of CH_4 and CO_2. Similarly, for products like recycled plastic or paper the equivalent carbon content should be determined, using the average composition of these materials to determine the carbon content. For emissions to the atmosphere, a bridge table may be compiled both in ton carbon and in CO_2 equivalents, as the latter links to the SEEA Central Framework air emission accounts.

Table 0.1: Carbon stock account structure

	Geocarbon					Biocarbon			Carbon in the economy			Carbon in the seas	Carbon in the atmosphere	Total
	Oil	Gas	Coal	Limestone and marl	Other	Terrestrial	Freshwaters and saline wetlands	Marine	Inventories	Fixed assets, cosumer durables	Waste	Total	Total	
Opening stock														
Additions to stock														
Natural expansion														
Managed expansion														
Discoveries														
Upwards reappraisals														
Reclassifications														
Imports														
Reductions in stock														
Natural contraction														
Managed contraction														
Downwards reappraisals														
Reclassifications														
Exports														
Net carbon balance														
Closing stock														

13.65 The carbon stock account complements other SEEA accounts. Although broader in coverage, carbon stock accounts are closely linked to the SEEA EA accounts. Carbon accounts can also provide information to support measures of the ecosystem services of carbon sequestration and retention of carbon. They are also closely linked to accounts of the SEEA Central Framework (e.g., physical assets of fossil fuels and minerals, carbon emissions to air, physical product flows to and from the rest of the world). Finally, the SEEA for Agriculture, Forestry and Fisheries (SEEA AFF) provides a detailed description of the links between these economic activities and emissions of carbon with a particular focus on the effects of land use, land use change and forestry (LULUCF) emissions.

13.66 The measurement of stocks and flows of carbon can support discussion of many policy relevant issues. These issues include the analysis of greenhouse gas emissions, sources of energy, deforestation and land use change, loss of productivity and biomass, and sources and sinks of carbon emissions. For example, carbon stock accounts can complement the existing flow inventories developed under the United Nations Framework Convention on Climate Change and the Kyoto Protocol thereto. Since carbon is also a common focus of policy response, for example carbon taxes, its direct measurement is of high relevance.

13.67 Further, carbon stock accounts can provide consistent and comparable information for policies aimed at, for example, protecting and restoring natural ecosystems, that is, maintaining carbon stocks in the biosphere. Combined with measures of carbon carrying capacity and land-use history, biosphere carbon stock accounts can be used to:

- Investigate the depletion of carbon stocks and the resulting CO_2 emissions due to conversion of natural ecosystems to other land uses
- Prioritize use of land for restoration of biological carbon stocks through reforestation, afforestation, revegetation, restoration and improved land management, taking account of differing trade-offs in respect of ecosystem services, biodiversity, food, fibre and wood production
- Identify land uses that result in carbon removal or retention.

13.4.4 Other climate change related accounts and indicators

13.68 Beyond the relevance of information from the ecosystem accounts and the carbon stock accounts, there are two other accounts that are highlighted. The SEEA Central Framework air emission account records the generation of air emissions by resident economic units by type of substance. These include the greenhouse gases CO_2, CH_4, N_2O and the F gasses. All emissions by establishments and households as a result of production, consumption and accumulation processes are included.

13.69 The GHG emissions by economic activities, as recorded in the SEEA, differ from the total emissions on a national territory or the emissions calculated according to the compilation guidelines of the IPCC. This is because different concepts and calculation methods underlie the different emission data. For instance, SEEA Air emission accounts include emissions due to international transport based on residence of economic units involved. Bridge tables provide insight in the relations between the different emission concepts.

13.70 Included in the scope the of SEEA Central Framework air emission accounts are emissions from cultivated livestock due to digestion (primarily methane), and emissions from soil as a consequence of cultivation and other land-use practices that affect soils, or other soil disturbances such as a result of construction or land clearance. Emissions from natural processes such as unintended forest and grassland fires, emissions from peatland, but also human metabolic processes are excluded. However, emissions from these sources are included in the carbon stock accounts.

13.71 In order to permit effective linking of physical flow data to monetary data, the physical flows of emissions are classified using the same classifications used in the SNA. The emissions recorded for CO_2 end CH_4 in the SEEA Central Framework air emission account directly link to the removal (managed expansion) of carbon from the atmosphere and the emission (managed contraction) of carbon by the economy as recorded in the carbon stock account.

13.72 The SEEA CF environmental activity accounts record transactions in monetary terms between economic units that may be considered environmental. Generally, these transactions concern activity undertaken to preserve and protect the environment. Transactions in environmental activity accounts are classified by the classification for environmental activities (CEA). Two classes are particularly relevant for climate change: EP 1 Protection of ambient air and climate, which includes activities aimed at the control of emissions of greenhouse gases, and RM 10 Management of mineral and energy resources, which includes activities related to energy saving and renewable energy production. Selecting these classes from the accounts provides data on the mitigation costs for climate change, the economic benefits that result from the energy transition with regard to labour and the contribution to GDP.

13.73 As well, there are a range of transactions, such as taxes and subsidies, that reflect efforts by governments, on behalf of society, to influence the behaviour of producers and consumers with respect to the environment. Payments and financial transactions relating to carbon taxes and emission permits are recorded in the SNA.

13.74 There is a wide range of indicators that may be derived from the various SEEA accounts concerning climate change. Examples include indicators of energy and emission intensity, indicators concerning carbon taxes and emission permits and indicators of expenditure on climate change related responses. The SEEA Applications and Extensions provides a range of guidance in this area in particular concerning the potential to undertake relevant structural decomposition analysis and footprinting which estimates the emissions embodied in goods and services that are imported (and exported) thus showing production and consumption perspectives. There is also the potential for data from the accounts to support climate change modelling in terms of implications of projected climate change scenarios on economic activity.

13.75 Various indicators can be derived directly from carbon stock accounts or in combination with other information, such as land cover, land use, population, and industry value added. The suite of indicators can provide a rich information source for policy makers, researchers and the public. For example, comparing the actual carbon stock of different ecosystems with their carbon carrying capacities can inform land use decision making where there are significant competing uses of land for food and fibre.

13.76 An indicator that can be derived from the carbon stock account is the ‘net ecosystem carbon balance’ which can be used as the metric for measuring carbon sequestration. This indicator relates to the change in the stock of carbon in selected reservoirs over an accounting period. Commonly the focus of net carbon balance measures is on biocarbon but, depending on the analysis, the scope of the measure may also include parts of geocarbon, carbon in the economy and carbon in other reservoirs. There are also links that can be made to support the measurement of SDG 13 “Take urgent action to combat climate change and its impacts”.

Annex 13.2: Carbon stock account

A13.12 The rationale for carbon stock accounting in the context of ecosystem accounting was discussed in section 13.4. The present annex provides some additional details on the structure and accounting entries related to the carbon stock account as presented in Table 0.1. The carbon stock account presented in that table provides a complete and ecologically grounded articulation of carbon accounting based on the carbon cycle and, in particular, the differences in the nature of specific carbon reservoirs. Opening and closing stocks of carbon are recorded, together with the various changes occurring between the beginning and end of the accounting period recorded as either additions to or reductions in the stock.

A13.13 Carbon stocks are disaggregated into geocarbon, biocarbon, carbon accumulated in the economy, carbon in the oceans (inorganic only) and carbon in the atmosphere.

A13.14 Geocarbon includes all carbon stored in the lithosphere, excluding all organic carbon stored in dead biomass.[4] Basically, carbon that is part of the Earth’s lithosphere is considered as geocarbon (or geological carbon: carbon present in the Earth’s bedrock and sediments, primarily from marine sediment deposits), as well as carbon formed originally in the Earth’s biosphere millions of years ago, that, after geological metamorphosis due to high pressure and temperatures in the Earth’s crust, was transformed into e.g., oil and gas (organic geocarbon). Organic carbon in soils and in peat deposits is included in biocarbon.[5] Where the information generated from the accounts is policy-focused, the priority should be given to reporting those stocks that are being impacted by human activity (e.g., fossil fuels).

A13.15 Biocarbon includes all organic carbon in the biosphere, i.e., carbon in living biomass (plants and animals) and dead biomass (soil organic matter and sedimentary organic matter)[6] Biocarbon includes biomass in crops, grass in meadows, which is thus not considered as carbon accumulated in the economy. Carbon stored in livestock, however, is considered as part of ‘carbon in the economy’. Carbon stored in timber products, including timber used for construction, is also included as part of ‘carbon in the economy’.

A13.16 Biocarbon is classified by type of ecosystem, at the highest level according to the three main realms of the Global Ecosystem Typology (marine, freshwaters and saline wetlands, terrestrial). These high-level classes can be further broken-down using level 3 of the IUCN GET. It is recommended to separately record carbon in agricultural and other anthropogenic systems, to

[4] Geocarbon is further disaggregated into oil, gas, coal resources, rocks (primarily limestone and marls), and minerals, e.g., carbonate rocks used in cement production, methane clathrates and inorganic carbon in marine sediments

[5] Soil is the layer of fine material covering the Earth’s land surface influenced by and influencing plants and soil organisms.

[6] For biocarbon in soils, for practical reasons only the top 30 cm were included in this study. In particular for peat and peaty soils, this results in a strong underestimation of the total stock of biocarbon in soils. This shortcoming in the current models also potentially influences C flows in the case of water table changes exceeding this depth.

allow the distinction between carbon removal and emissions between natural and semi natural ecosystems and anthropogenic ecosystems.

A13.17 The stability of the carbon stocks in the biosphere depends significantly on ecosystem characteristics. In natural ecosystems, biodiversity underpins the stability of carbon stocks by bestowing resilience and the capacity to adapt and self-regenerate (Thompson et al., 2009). Stability confers longevity and hence the capacity for natural ecosystems to accumulate large amounts of carbon over centuries to millenniums, for example, in the woody stems of old trees and in soil. Semi-modified and highly modified ecosystems are generally less resilient and less stable (Thompson et al., 2009). These ecosystems therefore accumulate smaller carbon stocks, particularly if the land is used for agriculture where the plants are harvested or grazed regularly.

A13.18 The atmosphere contains carbon mainly in the form of CO_2 and methane. The atmosphere is a receiving environment with regard to carbon from the primary reservoirs geocarbon and biocarbon but also from emissions from carbon used in the economy. On the other hand, carbon uptake from the atmosphere may take place by carbon sequestration in biocarbon. As CO2 and methane act as greenhouse gasses in the atmosphere, accounting for these flows is highly policy relevant.

A13.19 The oceans are the receiving environments for carbon released from primary reservoirs and for from its accumulations in the economy. Carbon in oceans includes only inorganic carbon: carbonates dissolved in seawater. Living and non-living organic carbon in oceans is part of biocarbon. Carbonate particulates (e.g., shells) in sediments are part of geocarbon.

A13.20 Accumulations in the economy, which are the stocks of carbon in anthropogenic products, are further disaggregated into the following SNA components: fixed assets (e.g., concrete in buildings, bitumen in roads, livestock); inventories (e.g., petroleum products in storage, excluding those included in agricultural ecosystems); consumer durables (e.g., wood and plastic products); and waste. In turn, these main asset categories can be further disaggregated into biobased (i.e., derived from plants or animals) and non-biobased (i.e., fossil fuels, mineral (inorganic) products and synthetic materials (plastics)). Accounting for waste follows the conventions of the SEEA Central Framework, where waste products (e.g., disposed plastic and wood and paper products) stored in controlled landfill sites are treated as part of the economy.

A13.21 The flows of carbon that occur within the economy are very significant and essential for understanding the interaction between economy and environment. The level at which geocarbon and biocarbon stock changes can be linked to the economy will determine the policy usefulness of the carbon stock account. This is particularly relevant in cases where raw materials can be extracted from different ecosystem types (e.g., biomass fuel from natural ecosystems or agricultural ecosystems; meat from agricultural ecosystems or semi-natural ecosystems) or from geocarbon reservoirs with different carbon contents and emissions profiles.

A13.22 Carbon stored through geo-sequestration (i.e., the managed injecting of gaseous CO_2 into the surface of the Earth) is treated similarly, as a flow within the economy (resulting in an increase in accumulations). Any subsequent release of carbon to the environment is treated as a residual flow with a reduction in accumulations in the economy matched by a corresponding increase in carbon in the atmosphere.

A13.23 The presentation of the row entries in the account follows the basic form of the asset account in the SEEA Central Framework; the entries being opening stock, additions, reductions and closing stock. Additions to and reductions in stock have been split between managed and natural expansion and contraction. Additional rows for imports and exports have been included, thus making the table a stock account, as distinct from an asset account.

A13.24 There are five types of additions in the carbon stock account:

- Unmanaged expansion, which reflects increases in the stock of carbon over an accounting period due to natural growth or the indirect effects of human activities. Effectively, this will be recorded only for biocarbon and may arise from climatic variation, ecological factors such as reduction in grazing pressure, and indirect human impacts such as the CO_2 fertilization effect (where higher atmospheric CO_2 concentrations cause faster plant growth).
- Managed expansion, which reflects increases in the stock of carbon over an accounting period due to direct human activities. This will be recorded for biocarbon in ecosystems and accumulations in the economy, in inventories, consumer durables, fixed assets and waste stored in controlled landfill sites, and also includes greenhouse gases injected into the earth. Basically, these reflect all increases in carbon stock due to carbon input flows from other reservoirs which are directly related to human activities. All emissions related to land use, land use change and forestry (LULUCF) are included here (or in managed contractions depending on the carbon stock).
- Discoveries of new stock, encompassing the emergence of new resources added to a stock, which commonly arise through exploration and evaluation. This applies exclusively to geocarbon.
- Reclassifications of carbon stocks, which will generally occur in situations where an ecosystem asset is used for a different purpose. For example, increases in carbon in semi-natural ecosystems following the establishment of a national park on an area previously used for agriculture would be offset by an equivalent decrease in agricultural ecosystems. In this case, it is only the particular land use that has changed, that is, reclassifications may have no impact on the total physical quantity of carbon during the period in which they occur.
- Imports are recorded to enable accounting for imports of produced goods (e.g., petroleum products) that contain carbon.

A13.25 There are five types of reductions recorded in the carbon stock account:

- Unmanaged contractions, which reflect natural losses of stock during the course of an accounting period. They may be due to changing distribution of ecosystems (e.g., a contraction of natural ecosystems) or biocarbon losses that might reasonably be expected to occur based on past experience. Unmanaged contraction includes losses from episodic events including drought, some fires and floods, and pest and disease attacks, and also includes losses due to volcanic eruptions, tidal waves and hurricanes.
- Managed contractions, which are reductions in stock due to direct human activities and include the removal or harvest of carbon through a process of production. This includes mining of fossil fuels and felling of timber. Extraction from ecosystems includes both those quantities that continue to flow through the economy as products (including waste products) and is recorded net of those quantities of stock that are immediately returned to the environment after extraction because they are unwanted—for example, felling residues. Managed contraction also includes losses as a result of a war, riots and other political events;

and technological accidents such as major toxic releases. All emissions related to land use, land use change and forestry (LULUCF) are included here (or in managed expansions depending on the carbon stock).

- Reclassifications of carbon stocks, which generally occur in situations where another environmental asset is used for a different purpose. For example, decreases in carbon in agricultural ecosystems following the establishment of a national park on an area used for agriculture would be offset by an equivalent increase in semi-natural ecosystems. In this case, it is only the particular land use that has changed; that is, reclassifications have no impact on the total physical quantity of carbon during the period in which they occur.
- Exports are recorded to enable accounting for exports of produced goods (e.g., petroleum products) that contain carbon.
- Catastrophic losses, which are not shown as a single entry but are allocated between managed contraction and unmanaged contraction. Catastrophic losses in managed contraction would include fires deliberately lit to reduce the risk of uncontrolled fires. For the purposes of accounting, reductions due to human accidents, such as rupture of oil wells, would also be included under managed contraction. Catastrophic losses could, however, be separately identified.

5 References

Statistics Netherlands, 2017, The SEEA EEA carbon account for the Netherlands https://seea.un.org/content/seea-eea-carbon-account-netherlands