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Draft Guidance Note

Issue B3 – Treatment of carbon flows in the SEEA CF

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Questions for the London Group:

- 1) **Do you agree to with the proposed definition for human-induced flows ?**
- 2) **Do you agree with the proposed accounting approach for human induced flows as described in the tables ?**
- 3) **Have we identified the main examples for human induced flows ? Are there others that need to be identified ?**
- 4) **What option do you prefer with regard to the inclusion of carbon flows related to LULUCF in the SEEA CF? Are there other options to be considered ?**

Option 1: Exclude (by convention) all land use related emissions and uptake in SEEA CF air emission accounts.

Option 2: Include LULUCF related emissions and uptake in SEEA CF air emission accounts as emissions from the economy and uptake into the economy.

Option 3: Include LULUCF related emissions and uptake in the SEEA CF air emission accounts as human-induced flows in nature.

- 5) **Have you any comments with regard to the proposed accounting approach for options 2 and 3 ?**
- 6) **Should emissions from land use change be allocated to a) the old land use, b) the new land use, or c) the activity involved in the land conversion ?**
- 7) **Do you agree with a more extensive description of a use table for the AEA and the examples identified? Are there other examples here that need to be described for the use table?**
- 8) **Should storage of carbon underground be described as a flow within the economy of a flow to the environment ?**
- 9) **Should either option 2 or 3 be chosen, do you agree to rename the account from the current 'Air Emission Accounts (AEA)' to 'Air Emissions and Removals Accounts (AERA)' ?**

1 Description of the issue

1.1 Introduction

1. This Guidance note addresses **Issue B3 – Treatment of carbon flows in the SEEA CF**. This issue investigates whether the physical supply and use tables (PSUT) of the SEEA CF can be extended to record certain human-induced flows that occur within the environment, in particular carbon flows related to land use, land use change and Forestry (LULUCF).
2. For issue B3 the following three sub issues have been identified:
 - A. **Human-induced flows:** Can we provide a general definition for the so-called human-induced flows, i.e. flows that occur within the environment but are human-induced, and indicate how these can be accounted for in the PSUTs?
 - B. **LULUCF emissions and removals:** Can LULUCF related carbon emissions and carbon uptake flows be included in SEEA CF, i.e. in the air emission accounts (AEA), and if yes, how should these flows be accounted for?
 - C. **Extension of the description of the air emissions accounts:** Can we provide a more elaborate description of the use table for the AEA and indicate what flows should be recorded here? Can a bridge table be added to the text of the SEEA CF?
3. The remainder of this Guidance note covers:
 - Motivation of the issue and current accounting treatment
 - Review of existing measurement and research
 - Alternative conceptual options and treatments
 - Recommendations on conceptual treatments
 - Other considerations in advancing the issue

1.2 Motivation for the issue

4. As defined in the 2012 SEEA Central Framework (SEEA-CF), physical flow accounts include relevant physical flows “(a) from the environment, (b) within the economy and (c) back to the environment” (SEEA-CF 3.10). Flows occurring within the environment are specifically excluded (SEEA-CF 3.23), though it is acknowledged that recording these flows may be “useful for analytical purposes.”
5. There are however several borderline cases, where it is not clear if a flow occurs within the economy or in the environment, and/or whether a flow crosses the economy-environment boundary. In particular there are certain flows that occur within the environment but are clearly human induced. In effect, “use” of an area implies the existence of some human intervention or management (SEEA-CF 2.24). Some of these cases are discussed briefly in the SEEA CF 2012.
6. Land use, land-use change, and forestry (LULUCF) is a sector defined by IPCC, that looks at both carbon emissions and carbon sequestration related to land use and land use changes (see annex). There is growing policy interest here as the management of terrestrial ecosystems (mainly forests)

provides several climate change mitigation options. LULUCF carbon removals and emissions are part of national and international climate mitigation targets, for example, as set for the Paris Climate Agreement in 2015.

7. The SEEA CF does not provide clear guidance how to treat emissions and uptake of CO₂ that result from land use and land use change. As a result, LULUCF emissions and uptake are not included in SEEA air emission accounts (AEA). This creates a mismatch between SEEA and IPCC data, which both in principle record 'anthropogenic' emissions.
8. It is worthwhile to revisit some of these issues to provide more clarification and guidelines than currently included in the current SEEA CF, or to propose an alternative treatment. Also, from a policy perspective, some of these flows (e.g. LULUCF, carbon capture and storage) are receiving more attention, and accordingly we should review their inclusion (or exclusion) in the SEEA accounting framework. Data on carbon emissions to the atmosphere play a key role in climate policies with regard to monitoring, policy evaluation and policy making for climate mitigation. The air emission account provides data to monitor the relation between emissions and economic development, but also provides data for all kinds of environmental-economic analyses, such as footprint calculations.
9. Flows related to LULUCF are a key example of human induced flows that are currently not included in scope for the physical flow accounts, according to the SEEA CF 2012. Other examples include Transboundary Pollutant Flows and Secondary Fine Particle Air Pollution (see also Chambers et al, 2024). These flows are all policy relevant. This warrants efforts to investigate if these flows can conceptually be included in the scope of the SEEA CF.
10. Finally, climate policies do not only focus on the supply side of air emissions, but also look at where the emissions end up (i.e. the use side). Carbon uptake in vegetation (LULUCF) is just one example how CO₂ can be captured and/or removed from the atmosphere. Carbon Capture and Storage (CCS), Carbon Capture and Utilisation (CCU) and Direct Air Carbon Capture and Sequestration (DACCS) are technologies that need to be adequately accounted for in the AEA. Carbon can also be captured and transported abroad by pipelines or shipping, which should be recorded as exports. All these topics warrant the inclusion and description of a use table in the AEA.

1.3 Current accounting treatment in SEEA CF

11. The air emissions accounts (AEA) are a subset of the material flow accounts and record the generation of emissions to air by resident economic units and by type of substance. The air emissions recorded in the AEA align with the general principles of material flow accounting (chapter 4) to record only emissions from economic activities. For this reason, emissions that originate from the environment are excluded from the scope.
12. With regard to emissions related to land use and land conversions the following paragraph is most relevant: par. 3.243 *Included within the scope of air emissions in the air emissions account is a range of other emissions that are the direct result of economic production processes, namely, the emissions from cultivated livestock due to digestion (primarily methane), and **emissions from soil as a consequence of cultivation or of other soil disturbances, arising, for example, from***

construction or land clearance. Emissions from natural processes such as unintended forest and grassland fires and human metabolic processes which are not the direct result of economic production are excluded.

13. Par. 3.243 clarifies that emissions from soils are included in the scope of the SEEA AEA as long as they result directly from certain economic activities such as agriculture or construction. At the same time it is stressed that emissions from natural processes, such as unintended forest and grassland fires, are to be excluded. Furthermore, by referring to land clearance this paragraph seems to imply that emissions due to land use changes are included in the scope.
14. With regard to removal / sequestration of gasses the following two paragraphs are relevant: par. 3.242 *Air emission accounts also **do not record the extent of the capture or embodiment of gases by the environment**, for example, carbon captured in forests and soil.* Par. 3.234 *Gaseous and particulate substances **generated through economic activity may be captured for use in other production processes or transferred between economic units for use in production or for storage (e.g., of carbon emissions).***
15. At first sight, par. 3.242 is clear on the exclusion of the capture/uptake of gases by the environment in the air emissions accounts. It is not clear, however, if this only refers to the 'natural environment' or also to the 'managed environment'. In other words, it is not clear if this statement includes the uptake of CO₂ as defined in LULUCF. Furthermore, it is also not clear whether the exclusion is based purely on conceptual reasons or that, by definition, the air *emissions* accounts should only include emissions and not uptake. Here, it is important to note that, looking beyond the AEA, CO₂ is recognized in the SEEA CF as an important natural input that should be recorded in the general physical supply and use tables (PSUTs). As such, SEEA CF does not preclude the recording of CO₂ uptake from the atmosphere. Paragraph 3.234 indicates that the AEA could go beyond just recording emissions by also including the capture or storage of CO₂ produced by economic activities. Thus, this leaves open the possibility of including the removals of CO₂ from the atmosphere due to economic activities in the AEA.
16. At present, the air emissions account consists only of a supply table. Since the focus is on the generation and release of residuals, there is no requirement that a complete PSUT be constructed. Rather, emphasis is on determining an appropriate scope for the measurement of air emissions which aligns with the scope and boundaries used in the compilation of the economic accounts. The possibility of including a use table is mentioned in the SEEA CF 2012, but this is not further elaborated.
17. In par. 3.254-3.256 the SEEA CF describes the relationship between air emissions accounts and other accounting frameworks. The current SEEA CF does not include bridge tables to describe the differences between the AEA and other frameworks.

2 Review of existing measurement and research

18. This Guidance note builds on research done over the past years, in particular the work by ISTAT and FAO for the SEEA Agriculture, Forestry and Fisheries (SEEA AFF), and two London group papers presented in 2023 and 2024.
19. This issue was first addressed by ISTAT and FAO some years ago during the compilation of SEEA AFF and was also discussed in the London group (Tubiello F., 2016; Vetrella G. et al., 2017). For the SEEA AFF it was concluded that all LULUCF emissions and uptake should be included, but acknowledged that this interpretation was 'at the edge of current SEEA understanding and applications' (FAO, 2016).

20. SEEA AFF defines removals as carbon sequestration that is the direct result of economic activity under ISIC A. Thus SEEA AFF complements SEEA CF para 5.85, by extending the concept of accounting for carbon sequestration in forest physical asset accounts, to other physical asset accounts relevant to SEEA AFF, consistently with IPCC guidelines.
21. In SEEA AFF removals linked to ISIC A01 and A02 activities are those generated by carbon sequestration due to specific land management 6 practices, including forest re-growth cycles, afforestation, cropland and grassland land set-asides, etc. These are also reported to UNFCCC as CO₂ under IPCC sector LULUCF, land use categories cropland, grassland and forestland, as well as land use change categories land converted to other land uses.
22. However, CO₂ removals linked to carbon capture or embodiment by the environment, for example, carbon capture in forests and soils that cannot be linked to economic activity, are not recorded in SEEA AFF, under the interpretation that embodiment by the environment in the SEEA CF refers to natural processes that are beyond the control of the economic activity being accounted for. This is consistent with UNFCCC/IPCC language, where carbon sequestration linked to natural processes, including CO₂ fertilization and nitrogen deposition, are excluded from accounting.
23. In the paper 'LULUCF and SEEA CF' presented in Pretoria, South Africa at the 29th Meeting London Group (Schenau, S. (2023)) LULUCF related carbon flows and options for inclusion in the SEEA CF was discussed. This paper was taken as the basis for section 3.2 of this Guidance note.
24. In the paper 'Accounting for Human-induced Flows in Nature' presented in Washington at the 30th meeting of the London Group (Matthew Chambers, Nils Brown, Kaia Oras, Aldo Femia, and Sjoerd Schenau (2024)) the concept of human-induced flows for physical flow accounting was discussed. This paper was taken as the basis for section 3.1 of this Guidance note.

3 Alternative conceptual options and treatments

3.1 Human-induced flows

25. In this section a new concept for physical flow accounting will be introduced, namely human-induced flows. We will propose a definition for these flows, a general accounting approach, and describe what specific flows could be described in the SEEA CF.

Defining human-induced flows

26. Here we address physical flows that have the following characteristics:
 - a. They occur within the environment.
 - b. They are the result of human (economic) activity.
 - c. They have meaningful, policy-relevant impacts.

These are all flows that are currently not included in SEEA-CF accounts.

27. Point a (that these flows occur within the environment) is the primary argument against the inclusion of the relevant flows in the physical supply and use tables (PSUTs) in the SEEA CF 2012, while points b and c (these flows result from human activity and have meaningful, policy-relevant impacts) would support their inclusion in some fashion.

28. Based on the points discussed above **human-induced flows** can be defined as *physical flows that are caused directly by human activity but occur within the environment rather than flowing between the economy and the environment, and which have meaningful, policy-relevant impacts*. This definition should be applied only to flows for which there is a short, well-established causal pathway from human activity to the flow in question, as higher-order indirect effects become significantly more difficult to rigorously enumerate or quantify¹.

Accounting for human-induced flows

29. Human-induced flows in nature can be accounted for by adding a sector-level category to the columns of the physical SUTs called “Human-induced flows in the environment,” with further disaggregation of this category representing the different processes or pathways by which these flows occur. For example, the air emissions physical SUTs could include in this category columns such as “Forest—land use”, “Wetland—land use change”, “Secondary PM 2.5 formation”, “Transboundary flows”, etc. A column for Human-induced flows in the environment is to be included in both the supply and use table (see table ...).
30. In many cases, these human-induced flows in nature highlight areas where the boundary between the economy and the environment is somewhat blurred. The current SEEA-CF draws the line between the economy and the environment all the way on the economy side of this area. Assigning human-induced flows in nature to industries could redraw the boundary between economy and environment quite far on the environment side, blurring this essential boundary.
31. By instead recording these flows in their own category, this proposal allows us to retain the existing definition of the economy-environment boundary, while still accounting more fully for the impacts of human economic activity on the environment. This approach also avoids the difficulties that could arise in trying to assign human-induced flows in nature to industries, since these natural flows are assigned instead to the processes or pathways through which they occur. This approach is flexible enough to accommodate the examples described below, and can be readily adapted to accommodate other human-induced flows in nature as well. It should be stressed that the choice of which columns (if any) to include under the “Human-induced flows in nature” heading will be made by individual countries, in response to their unique circumstances and needs.
32. The proposed extension for the treatment of human-induced flows not only entails that these flows are accounted for the SEEA physical flow accounts, but also that they are included in the totals that can be derived from the tables. This may thus affect the indicators that are often based on these totals.

Examples of human-induced flows

33. Below we list several (possible) examples of human-induced flows that could be described in the SEEA CF. This list is not comprehensive, but includes flows that will be relevant for most countries.

¹ A related concept is that of natural resource residuals (SEEA CF 3.49-3.50): natural resource inputs that are not incorporated into production processes but instead are immediately returned to the environment. Examples include the flaring and venting of natural gas, discarded catch in fishing and felling residues from the harvesting of natural timber resources. Natural resource residuals are recorded in the PSUT as a flow from the environment to the environment, i.e. a flow that stays within the environment.

In principle countries could add other human-induced flows, following the general concepts described above and based on national policy priorities

34. **Carbon Emissions and carbon uptake related to land use, land use change and forestry (LULUCF)** could be considered as human-induced flows. These flows are highly policy relevant but currently not recorded in the SEEA CF. These flows mainly occur within the environment, but could also be interpreted as flows from and to the economy. This is further discussed in section 3.2.
35. **Carbon Dioxide Removal (CDR)** refers to anthropogenic activities that remove CO₂ from the atmosphere and either use it in production or durably store it in geological, terrestrial, or ocean reservoirs. CDR could be recorded as a human-induced flow, but also as a flow into the economy (based on how the storage is interpreted). This is discussed in more detail in section 3.3.
36. **Secondary Fine Particle Air Pollution:** Fine particulate matter (PM 2.5) is an important non-GHG air pollutant, with a variety of serious health impacts, both acute and chronic. Ambient PM 2.5 consists of both *primary* PM 2.5, emitted directly as solid or liquid particles or as hot vapours that condense into particles upon cooling, and *secondary* PM 2.5, formed in the atmosphere through chemical reactions between various gases, including sulphur dioxide (SO₂), nitrogen oxides (NO_x), and various organic compounds². Secondary PM 2.5 is a major portion (a majority, in some cases) of total ambient PM 2.5 (Zhang, et al., 2022; Fine, Sioutas, & Solomon, 2012). Consequently, accounting for primary PM 2.5 but not secondary PM 2.5 presents an inaccurate picture of the relationship between economic activities that emit PM 2.5 and ambient PM 2.5 exposure.
37. Secondary Fine Particle formation takes place within the atmosphere (i.e. the environment). Attributing secondary PM 2.5 to industries presents serious difficulties, since the chemical reactions which produce secondary PM 2.5 may have as inputs emissions from multiple different sources within the economy, from other economies, or from nature itself. Therefore Secondary Fine Particle Air Pollution is best considered as an human-induced flow.
38. The table below (taken from the Washington LG paper) shows how secondary fine particle formation can be accounted for. Newly formed pollutants are recorded in the Supply table; in this example, under the “PM 2.5-forming Reactions” column. The Use table records the reactants that serve as inputs to these reactions. These reactants are no longer found separately in the air; this is reflected in the Use table by being listed under (in this example) “PM 2.5-forming Reactions” rather than under “Environment.” Consultation with specialists in the appropriate fields will be critical to properly characterize these pollutant-forming reactions, as they are complex and dependent on a variety of factors³.

² These organic compounds may be natural or anthropogenic in origin.

³ The figures given in this chart are illustrative examples only and should not be taken as a numerically accurate representation of the reactions which transform emissions into secondary PM 2.5.

Supply	Industries						Human-Induced Flows in the environment		Total
	Agriculture	Utilities	Manufacturing	Transportation	Gov't	Households	Particle-Forming Reactions	Imports	
Primary PM 2.5	70	100	40	120	35	40		20	425
Secondary PM 2.5							500	50	550
SO2	0	130	60	50	0	0		15	255
NOx	0	100	60	200	50	150		70	630
NH3	350	2	2	6	5	15		160	540
VOCs	80	15	250	75	80	200		60	760

Use	Human-Induced Flows in the environment		Environment	Total	
	Particle-Forming Reactions	Exports	Atmosphere		
Primary PM 2.5			42	383	425
Secondary PM 2.5			55	495	550
SO2		100	25	130	255
NOx		200	60	370	630
NH3		200	55	285	540
VOCs		300	75	385	760

39. **Transboundary flows:** Pollutants emitted to water or air by economic activities in one country may flow into other countries, causing harms downstream. Understanding these flows is critical for understanding the distributional impacts of pollution⁴, but they are explicitly out of scope under the current SEEA-CF (SEEA-CF 3.241).
40. These transboundary flows of pollutants can be considered as human-induced flows, and be added to the PSUTs through import and export columns under the new “Human-Induced Flows in Nature” category, as shown in the table above.
41. Beside the above mentioned examples there are other flows that could potentially be incorporated into the PSUTs: for example landslides resulting from human-induced erosion, mobilization of heavy metals in groundwater due to human-induced changes in groundwater level, etc.

3.2 Inclusion of LULUCF emissions and removals in the SEEA CF

Conceptual considerations for inclusion or exclusion of LULUCF related flows

42. Here we start with addressing the issue: *Should LULUCF emissions and removals be included in the scope of the SEEA AEA or not?* This means that we must look at the following two questions:
- Do LULUCF carbon removals concur with the definition of natural inputs as defined in SEEA CF, i.e. *physical inputs that are moved from their location in the environment as a part of economic production processes or are directly used in production ?*
 - Do LULUCF emissions concur with the definition of air emissions as defined in SEEA CF, i.e. *gaseous and particulate substances released to the atmosphere by establishments and households as a result of production, consumption and accumulation processes ?*

⁴ Particularly for water pollutants and non-GHG air pollutants.

43. We start by looking more closely at the general definition and scope of IPCC emissions, and LULUCF emissions and removals in particular. The scope of IPCC emissions includes all **anthropogenic emissions**, which are defined as *emissions of greenhouse gases (GHGs), precursors of GHGs and aerosols caused by human activities* (IPCC Glossary, 2022). These activities include the burning of fossil fuels, deforestation, land use and land-use changes (LULUC), livestock production, fertilization, waste management and industrial processes. Here we see in principle a close correspondence with the definition of air emissions in SEEA (see above): both are focused on emissions induced by human activities, which we can assume are the same as economic activities as defined in the SNA/ SEEA context.
44. LULUCF covers anthropogenic emissions and removals of GHG in managed lands, excluding non-CO₂ agricultural emissions. Following the 2006 IPCC Guidelines for National GHG Inventories and their 2019 Refinement, **'anthropogenic' land-related GHG fluxes are defined as all those occurring on 'managed land'**, that is, **'where human interventions and practices have been applied to perform production, ecological or social functions'**. Furthermore, anthropogenic removals refer to the withdrawal of GHGs from the atmosphere **as a result of deliberate human activities**. These include enhancing biological sinks of CO₂ and using chemical engineering to achieve long-term removal and storage. Finally, emissions and removals related to land use change (for example deforestation) by definition are human-induced. From this we can deduce that LULUCF emissions and removals in principle include only flows that are the result of human interventions. Accordingly, from this we may conclude that LULUCF flows would be within scope of SEEA and thus should be included in the AEA.
45. In this regard, we may also look at how SEEA CF currently deals with the boundary between the environment and the economy for flows related to biological resources (par. 5.54-5.58). The SEEA CF makes a distinction between cultivated and non-cultivated biological resources. In the case of cultivated resources, a complete accounting of physical flows is required, i.e. including the recording of the nutrients and other substances absorbed from the environment as natural inputs, since the biological resources themselves are already "in" the economy. The physical flows resulting from metabolism (e.g., photosynthesis and respiration) and transpiration of cultivated biological resources either are embodied in products or return to the environment as residuals. For non-cultivated biological resources, the use of CO₂, oxygen and nitrogen, and the uptake of soil nutrients and water are treated as flows within the environment and only the actual harvest of resources is considered to flow into the economy.
46. According to the SNA2025 nearly all biological resources that fall within the SNA asset boundary are now considered as cultivated, with the exception of biological resources yielding once-only products which in practice are only the fish resources in open seas (see also OECD Measuring natural resources in the national accounts: a compilation guide). This means that all timber resources (that fall within the SNA asset boundary) are considered cultivated, and CO₂ uptake by these resources should thus be considered as a natural input flow (and thus as such be recorded in the SEEA CF).
47. A non-conceptual argument to include LULUCF in the AEA is that these flows are highly policy relevant. Particularly for countries with a lot of forests, LULUCF provides a way of recording mitigation options through the sequestration of carbon from the atmosphere. Likewise, some countries may have large emissions from organic soils underlying pastures, which otherwise would not be recorded. Exclusion of LULUCF would also perpetuate that difference between AEA

and IPCC data. Users of the data may not understand why these ‘anthropogenic’ emissions are not included in SEEA.

48. There are however also arguments against including LULUCF in the SEEA AEA. First, more in general, conceptually flows occurring solely within the environment are out of scope of physical supply and use tables (SEEA CF par 3.23). The one example provided in the SEEA is ‘evaporation and precipitation of water and soil moved through soil erosion’. It could be argued that LULUCF emissions and removals are quite similar as the example just cited, and thus should also be interpreted as flows within the environment. For example, emissions from organic soils in principle primarily reflect a natural process occurring within the natural environment. To some degree (or in certain cases) this may be human-induced (drainage of peat soils for example), but the point is that these emissions may also (in many cases) not be anthropogenic in origin.
49. Second, and more specifically, emissions and removals resulting from land use may not always correspond to emissions and natural inputs as defined in the SEEA. To investigate this, we have to look more closely at the definitions for land use. According to the IPCC, land use is defined as *the total of arrangements, activities and inputs undertaken in a certain land cover type (a set of human actions; IPCC glossary, 2022)*. In SEEA CF, land use reflects both (a) *the activities undertaken and (b) the institutional arrangements put in place for a given area for the purposes of economic production, or the maintenance and restoration of environmental functions* (SEEA CF par 5.246). In effect, “use” of an area implies the existence of some human intervention or management. Land “in use” therefore includes, for example, protected areas that are under the active management of institutional units for the purpose of excluding economic or human activity from that area. Furthermore, some areas are “not in use”, although they may have a use in supporting ecosystems and biodiversity.
50. From these definitions we can deduce that IPCC and SEEA use a very similar definition of land use, but also that land use is much broader than the economic activity taking place on the land. By looking at the land use classification from the SEEA CF (see table below), we can distinguish three categories 1) land use directly associated with an economic production/ consumption activity, 2) land use associated with and environmental management activity (in other words, land under environmental protection), and 3) land not in use.

1 Land	
1.1 Agriculture	Economic production activity
1.2 Forestry	Economic production activity
1.3 Land used for aquaculture	Economic production/ consumption activity
1.4 Use of built-up and related areas	Economic production activity
1.5 Land used for maintenance and restoration of environmental functions	Environmental management activity
1.6 Other uses of land n.e.c.	
1.7 Land not in use	land not in use

Table: SEEA CF land use classification

51. In principle environmental management activities could be seen as a specific kind of production activity. However, ecosystem management is very different from for example production activities involving combustion processes (CO₂ emissions) or agricultural processes (methane emissions). We conclude that land use is a broader concept than the production activity taking

place on the land, and accordingly, not all emissions / uptake associated with land use may be directly associated with an economic activity.

52. The main challenge with the IPCC guidelines for LULUCF is that they use a very broad interpretation for land management, i.e. all human interventions and practices that have been applied to perform production, ecological or social functions. The guidelines also acknowledge that: ‘Since managed land may include carbon dioxide (CO₂) removals not considered as ‘anthropogenic’ in some of the scientific literature assessed in this report (e.g., removals associated with CO₂ fertilisation and N deposition), the land-related net GHG emission estimates from global models are not necessarily directly comparable with LULUCF estimates in National GHG Inventories’. (IPCC 2006, 2019). Including LULUCF related flows thus may ‘blur’ the boundary between the economy and the environment, as all terrestrial ecosystems that are somehow managed would be included into the economic sphere.
53. Harvested wood products (HWP) are wood-based materials harvested from forests, which are used for products such as furniture, plywood, paper and paper-like products, or for energy. This flow (i.e. the harvest flow) would be recorded in the general PSUT, but not as such in the AEA. In the AEA the related flow would only be recorded after use of the product when the actual combustion of the wood products takes place and the emission to the atmosphere occurs⁵.
54. As an interim conclusion we may state that :
- a) **Carbon emissions and uptake related to land use** in principle are anthropogenic in origin and thus are the direct result of economic activities. As such they could be defined as emissions and natural input as defined in SEEA CF and thus be included in the AEA. However, a concern is that the IPCC definitions for these flows use a very broad definition of land use which may not be fully consistent with the SEEA environment-economy boundary.
 - b) **Carbon emissions and uptake related to land use change** are always a direct result of an economic activity and thus should be included in the AEA.
 - c) **Harvested wood products (HWP)** represents a product flow and thus should not be recorded in the AEA.

Options for accounting for LULUCF related flows

55. Based on the discussion above, we can formulate the following three options on how to account for LULUCF related flows in the SEEA CF:

Option 1: Exclude (by convention) all land use related emissions and uptake in SEEA CF air emission accounts. This would follow the argumentation that these flows (mainly) represent flows that occur within the environment and are (generally) not directly related to production or consumption activities. Emissions related to land use change should be recorded, but this was (probably) already the case in the SEEA CF 2012. This option thus would not change anything in the current recording of the AEA.

⁵ Also note that GHG emissions that result directly from the harvesting of the wood and the production of the wood products would be included in the AEA.

Option 2: Include LULUCF related emissions and uptake in SEEA CF air emission accounts as emissions from and uptake into the economy, following the argumentation that these flows are the direct result of economic activities. Accordingly, we would have to clarify in the SEEA CF that these flows are within scope of the AEA and advise users to follow the LULUCF definitions/data. A key advantage would be that LULUCF data would directly concur with the corresponding data in the AEA. In the text it may be stressed that only emissions/uptake related to active human management should be included.

Option 3: Include LULUCF related emissions and uptake in the SEEA CF air emission accounts as human-induced flows in nature (see section 3.1). This option recognizes that human activities impact terrestrial carbon sinks through land use, land-use change, and forestry, but reflects the consideration that these flows in principle occur within the environment. So, the key difference between the last two options is that for option 2 these are recorded as flows between the economy and the environment whereas for option 3 these are recorded as flows within the environment.

56. Below we show and discuss how the accounting for options 2 and 3 would look in the AEA, using some example data for LULUCF.

Example IPCC data for LULUCF and combustion

LULUCF	kton CO2	Combustion	kton CO2
Forest land		Agriculture	110
Emissions from organic soils	30	Forestry	20
Carbon uptake	-400	Mining and manufacturing	580
Land converted to forests	-45	Government	90
		Households	250
Cropland			
Emissions from organic soils	80		
Land converted to cropland	25		
Wetlands			
Emissions from soils/ sediment	15		
Land converted to wetland	5		
Settlements			
Land converted to settlements	35		
Harvested wood products	20		

57. **Option 2: allocate the emissions and uptake to the relevant economic sectors.** According to this option carbon emissions and uptake related to land use should be allocated to the production activity directly related to the land use. For example, emissions from agricultural lands are to be allocated to Agriculture (ISIC A). The allocation may not always be straightforward. For (semi) natural areas, protected and non-protected, there often is no clear link to an economic activity.

In this case the allocation should be to the activity responsible for the management of the land (which in many cases may be the government). For settlements there may be multiple economic activities involved, including those of households. Here emissions should be split out to the different activities or (by default?) be allocated to households.

58. For emissions related to land use change it is more complicated. For example, when a forest is cleared to make way for agriculture (deforestation), emissions may be attributed to the forestry sector (the old land use), the sector active in the actual clearing of the land (also the forestry sector) or to agriculture (the new land use). There are both valid arguments for allocation to the old or new land use. It is proposed here to allocate by default the emissions to the economic activity that is active in the new land use (which could be a production activity but also a consumption activity, i.e. households). The main argument is that the new land use is the driver for the land use change and thus for the related emissions (or uptake).
59. The tables below show how the recording of these flows in the AEA would work for this option. Adding uptake from the atmosphere would also introduce a use table (see also section 3.3). Based on the supply and use tables also the net emissions / uptake per sector can be calculated.
60. To facilitate the compilation of the accounts, a simplified structure for the Land Use and Land Use Change (LU-LUC) classes could be adopted in the proposed tables. As the primary aim is to provide policymakers with data that more effectively support the implementation and evaluation of policies on afforestation, reforestation, and deforestation, we propose to breakdown land use emissions into two classes only:
 - i. Forest land remaining forest land (FL)
 - ii. Other types of land use (OL)

A similar approach could be used for Land Use Change, which could then be represented by the following categories:

- i. Newly converted forest land (OL-FL)
This class should capture afforestation and reforestation.
 - ii. Forest land converted to other types of land use (FL-OL)
This class should capture deforestation.
 - iii. Other lands converted to other lands (OL-OL)
61. To further enhance the clarity of the SEEA terminology, the class “Newly converted forest land” may be renamed “Afforestation/Reforestation”, while “Forest land converted to other types of land use (FL-OL)” could be referred to as “Deforestation”. In such a case, however, it would be essential to provide precise definitions for these labels. Below, we present the definitions as outlined in the Global Forest Resources Assessment (FRA) programme, coordinated by the Food and Agriculture Organization (FAO):

Afforestation is the conversion from other land uses into forest land, or the increase of the canopy cover to above the 10% threshold. It includes areas actively converted into forest through silvicultural measures, as well as natural transitions (e.g., abandoned agricultural land). The change must be long-term, defined as ten years or more.

Reforestation is the re-establishment of forest formations after a temporary condition with less than 10% canopy cover due to human-induced or natural perturbations. The

area is considered forest if the canopy cover is expected to return to above 10% within a short-term period, defined as less than ten years.

Deforestation is the conversion of forest land to another land use or the long-term reduction of tree canopy cover below the 10% threshold. It implies a permanent loss of forest cover due to continued human or natural disturbance. It excludes areas where trees are removed but expected to regenerate naturally or through forestry practices.

To maintain continuity with previous practices and ensure consistency with the current approach adopted under IPCC reporting, it may be appropriate to include two different sub totals in the tables:

- i. Total excluding LULUCF
This would be the same as in the SEEA-CF 2012
- ii. Total including LULUCF
Which would represent the new total as in the SEEA-CF 2028

CO ₂ Emissions	Economy (ISIC sections/divisions)						Environment	Total
	Crop and animal production, hunting and related service activities	Forestry and logging	Manufacturing	Construction	Public administration and defence; compulsory social security	Households		
Supply								
Combustion	110	20	580		90	250		1050
<i>Fossil fuel</i>								
<i>Biomass</i>								
Non-Combustion								
Total excluding LULUCF	110	20	580		90	250		1050
Land Use	80	30			15		400	525
<i>Forest land remaining forest land (FL)</i>		30						
<i>Other type of land use (OL)</i>								
Land Use Change	25			35	5		45	110
<i>Newly converted forest land (OL-FL)</i>								
<i>Forest land converted to other type of land use (FL-OL)</i>								
<i>Other lands converted in other lands (OL-OL)</i>	25			35	5		45	110
Total including LULUCF	215	50	580	35	110	250	445	1685
CO₂ Removals	Economy (ISIC sections/divisions)							
Use	Crop and animal production, hunting and related service activities	Forestry and logging	Manufacturing	Construction	Public administration and defence; compulsory social security	Households	Environment	Total
Total excluding LULUCF							1050	1050
Land Use		400					125	525
<i>Forest land remaining forest land (FL)</i>		400						
<i>Other type of land use (OL)</i>								
Land Use Change		45					65	110
<i>Newly converted forest land (OL-FL)</i>		45						
<i>Forest land converted to other type of land use (FL-OL)</i>								
<i>Other lands converted in other lands (OL-OL)</i>								
Total including LULUCF	0	445	0	0	0	0	1240	1685
Net emissions	215	-395	580	35	110	250	-795	

62. **Option 3: record LULUCF flows as human-induced flows.** In this option, the LULUCF flows are also recorded in the AEA, but not as flows directly to and from economic activities. Instead, the flows are recorded as they actually occur, namely to and from the respective terrestrial ecosystems and the atmosphere⁶. This would be done by introducing the main land use categories under the column heading ‘human-induced flows in the environment’ (see also section 3.1). A key advantage of this option is that there is no need to allocate flows to economic activities.

63. This recording requires a more complex setup of the AEA (i.e. more complex than option 2) with the additional entry of land use types (or ecosystem types). Another disadvantage is that this way of recording leaves it unclear whether LULUCF emissions / uptake are included in the total (net) resident emissions, a key indicator derived from the AEA. In principle, recording these flows taking place within the environment seems to imply that they are not (unless we decide and make it clear in the text that this is otherwise).

CO ₂ Emissions	Economy (ISIC sections/divisions)						Total excluding LULUCF	Environment					Total including LULUCF		
	Supply	Crop and animal production, hunting and related service activities	Forestry and logging	Manufacturing	Construction	Public administration and defence; compulsory social security		Households	Human induced flows					Atmosphere	
Forest land remaining forest land (FL)							Other type of land use (OL)		Newly converted forest land (OL-FL)	Forest land converted to other type of land use (FL-OL)	Other lands converted in other lands (OL-OL)				
Combustion	110	20	580		90	250	1050								1050
Fossil fuel															
Biomass															
Non-Combustion															
Land Use								30	95					400	525
Land Use Change													65	45	110
Total	110	20	580	0	90	250	1050	30	95				65	445	1685

CO ₂ Removals	Economy (ISIC sections/divisions)						Total excluding LULUCF	Environment					Total including LULUCF		
	Use	Crop and animal production, hunting and related service activities	Forestry and logging	Manufacturing	Construction	Public administration and defence; compulsory social security		Households	Human induced flows					Atmosphere	
Forest land remaining forest land (FL)							Other type of land use (OL)		Newly converted forest land (OL-FL)	Forest land converted to other type of land use (FL-OL)	Other lands converted in other lands (OL-OL)				
Combustion & Non-Combustion														1050	1050
Land Use								400						125	525
Land Use Change										45				65	110
Total								400		45				1240	1685

64. The table below summarizes the advantages and disadvantages of the three options discussed above:

	Advantages	Disadvantages
Option 1	<ul style="list-style-type: none"> No changes with respect to the SEEA 2012 needed 	<ul style="list-style-type: none"> No recording in SEEA of these anthropogenic flows No recording in SEEA of these policy relevant flows

⁶ LULUCF related flows are restricted to the terrestrial domain and leave out uptake/ emissions from the marine domain, probably because these are considered as not anthropogenic.

		<ul style="list-style-type: none"> Creates (another) difference between the AEA and IPCC
Option 2	<ul style="list-style-type: none"> Inclusion of these policy relevant flows in the AEA Recognition of these anthropogenic flows as flows to and from the economy Consistency with IPCC Allocation to economic activities Calculation of net emissions/ uptake 	<ul style="list-style-type: none"> Economy-environment boundary becomes less transparent (?) Alignment with LULUCF causes possibly too wide a scope to be included Difficulties to allocate to economic activities
Option 3	<ul style="list-style-type: none"> Inclusion of these policy relevant flows in the AEA Consistency with IPCC (?) Recording of these flows as they actually occur No apparent change in the economy-environment boundary 	<ul style="list-style-type: none"> Status of these human-induced flows may be unclear to user of the data → not included in total emission by residents More complex setup of AEA tables No allocation to economic activities Emissions related to land use change not recorded as emissions from economic activities

65. The supply and use tables proposed for options 2 and 3 have been developed with reference to carbon dioxide (CO₂). However, similar tables could also be constructed for other greenhouse gases, particularly methane (CH₄) and nitrous oxide (N₂O).

3.3 Extension of the description of the air emissions accounts

The use table of the air emission account

66. The use table of the air emission accounts records where the air emissions produced by economic activities end up. This will primarily be the environment (the atmosphere), which is also the reason that, until now, the use table for the air emission accounts was not further developed. There are, however, several new techniques and processes whereby emissions are captured and stored and thus are not emitted to the atmosphere. This is discussed in more detail below, along with how these flows should be accounted for in the use table.

67. **Carbon Capture and Storage (CCS)** involves capturing carbon dioxide (CO₂) emissions from industrial sources and power plants, then transporting and storing it underground to prevent its

release into the atmosphere. It is a relatively new technique that has been developed to reduce emissions to the atmosphere and mitigate climate change.

68. The carbon is typically stored in deep geological formations, for example empty gas fields. These underground formations could be considered as being part of the environment, and thus the storing of carbon as a flow to the environment. However, this underground storage, in principle, is 'controlled storage', and thus could also be considered as storage within the economy (accumulation). There is a similarity here with storage of waste in controlled landfills, which in SEEA also considers as storage within the economy.
69. Based on this, there are two options for recording CCS related flows in the use table. The first option is to allocate them under 'environment', i.e. creating a separate column in the use table (geological formations), separate from the column 'atmosphere'. This option thus considers underground carbon storage as a flow from the economy to the environment. The second option is to record it as a flow within the economy, i.e. considering underground storage as being part of the economy. In this case, the flow would be allocated in the use table to 'accumulation' or to the economic activity that is responsible for the storing the CO₂ (which, according to the ISIC rev.5, would be ISIC 39 Remediation and other waste management service activities). This recording would be more in line with the general idea of CCS, i.e. that carbon is removed from the environment to cause no further harm with regards to climate change.
70. **Carbon Capture and Utilization (CCU)** refers to a range of applications through which CO₂ is captured and used either directly (i.e. not chemically altered) or indirectly (i.e. transformed) in various products, effectively transforming CO₂ from a residual into a resource. Examples of this include carbon that is captured either directly (e.g., to fertilize greenhouses, in beverages) or as an ingredient in new products (e.g., concrete, fuels, chemicals).
71. CCU represents a flow within the economy, i.e. a flow from the economic activity that emits the CO₂ to the economic activity that captures the CO₂ and transforms it into a product. Accordingly, this flow should be allocated to the latter economic activity in the use table, i.e. to the economic activity that uses the CO₂ and transforms it into a product.
72. **Carbon Dioxide Removal (CDR)** refers to anthropogenic activities that remove CO₂ directly from the atmosphere and durably store it in geological, terrestrial, or ocean reservoirs (IPCC). CDR encompasses a wide array of approaches, including direct air capture (DAC), coupled to durable storage, enhanced mineralization, and ocean-based CDR. These approaches are still new and experimental but may become important in the near future. CDR includes also long-term carbon sequestration in biomass (i.e. LULUCF related carbon sequestration), which was discussed in the previous section.
73. Flows related to Carbon Dioxide Removal (DAC, enhanced mineralization and ocean-based CDR) are an example of human-induced flows, i.e. flows that occur within the environment but that are the direct result of human activities. If the storage occurs deep underground, then the recoding should be similar as for CCS (see options discussed above). For ocean-based CDR, this seems a clear case for human-induced flows.
74. The table below provides an overview of the recoding of these flows in the use table (with the different options for CCS, CDR-DAC and carbon flows related to LULUCF **in red**).

Supply	Economy				Environment			
	Industry A	Industry B	Industry ISIC		Human induced flows			Atmosphere
			39	Accumulation	Geological formations	Oceans	Eosystems	
CCS	80							
CCU	50							
CDR - DAC								40
CDR - Oceans								30
CDR - carbon sequestration								100

Use	Economy				Environment			
	Industry A	Industry B	Industry ISIC		Human induced flows			Atmosphere
			39	Accumulation	Geological formations	Oceans	Eosystems	
CCS			80	80	80			
CCU		50						
CDR - DAC			40	40	40			
CDR - Oceans							30	
CDR - carbon sequestration		100						100

Bridge tables

75. A bridge table shows how data from a SEEA account relates to data recorded in other frameworks, for example IPCC. Below we describe a general bridge table for inclusion in the SEEA CF for air emission accounts (based on the bridge table in the Eurostat AEA questionnaire).

1	Total CO2 emissions by economic activities
2	<i>less National residents abroad</i>
2,1	- National fishing vessels operating abroad
2,2	- Land transport
2,3	- Water transport
2,4	- Air transport
3	<i>plus Non-residents on the territory</i>
3,1	+ Land transport
3,2	+ Water transport
3,3	+ Air transport
4	- Combustion of biomass (short cyclic CO2)
5	Total CO2 emissions as reported to the UNFCCC

76. This bridge table describes the differences between total resident-based CO₂ emissions from the AEA and the total national CO₂ emissions according to the IPCC guidelines. The main bridging items are emissions by national residents abroad and emissions by non-residents abroad. These can be further disaggregated by mode of transport.
77. An additional bridging item that could be added is emissions from the combustion of biomass (short cyclic CO₂), which is not included in the IPCC data. In principle (although the text in SEEA CF could be further clarified on this) these emissions are included in the AEA of the SEEA.
78. There may be some other differences which stem from the way emission from mobile sources are calculated according to the IPCC guidance rules. However, these may be too detailed to be described in the SEEA CF. For this a bridging item for 'other discrepancies' may be added.

79. In principle bridge tables could also be added for other physical flows, in particular for the energy flow accounts (which will have basically the same set up as for the table above).

Links between the AEA and ecosystem services from the SEEA EA

80. Ecosystem accounting (SEEA EA) places a complementary measurement focus on the role of ecosystems in mitigating climate change through their ability primarily to remove carbon from the atmosphere and to store carbon. Global climate regulation services reflect ecosystem contributions to reducing concentrations of GHGs in the atmosphere and stabilizing the climate and in turn avoiding damages that arise due to climate change (SEEA EA par. 6.107).
81. In SEEA EA, two components, carbon retention and carbon sequestration, are considered in the measurement of global climate regulation services, where carbon sequestration is most relevant for the AEA, and the discussion of LULUCF related flows. The carbon sequestration component of the service reflects the ability of ecosystems to remove carbon from the atmosphere. In measuring this component, it is assumed that carbon sequestration concerns only carbon that is expected to be stored for long periods of time. This may involve storage within an ecosystem asset (e.g. a mangrove or wetland) or another form of storage (e.g. in the economy). Carbon that is sequestered but not expected to be stored (e.g. in crops) should be excluded from scope (SEEA EA par. 6.114). In principle net carbon sequestration should be recorded, i.e. correcting from emissions from soils etc.
82. In SEEA EA all carbon sequestration by ecosystem assets is in scope, i.e. regardless of management regimes, ownership etc. A key difference between LULUCF related flows and carbon sequestration in the SEEA EA is thus that the first only considers managed ecosystems. For example, wetlands are often considered as unmanaged and are therefore considered beyond the scope of the UNFCCC. Also, carbon sequestration in marine environments is outside the scope of LULUCF.

Links between the AEA and the carbon stock account

83. The carbon stock account as described in SEEA EA chapter 13.4.3 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.
84. Carbon stocks are disaggregated into geocarbon (carbon stored in the geosphere), 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. Of relevance here is the recording of flows between biocarbon, carbon in the economy and the atmosphere.
85. The carbon stock account is closely linked to the accounts of the SEEA Central Framework (e.g. the physical asset accounts for fossil fuels and biological resources, but also physical flows accounts carbon, i.e. emissions to air, physical product flows to and from the rest of the world etc.). Inclusion of LULUCF flows may have consequences for the carbon stock account. Basically, option 2 would entail that emissions and uptake of managed ecosystems should be regarded as flows between the economy and the atmosphere and not as flows between biocarbon and the atmosphere. The question is if this indeed what we want to record here (to be consistent with the AEA). For option 3 (human-induced flows), in principle these flows still can be considered as flows between biocarbon and the atmosphere.

3.4 Some final considerations for the air emission accounts

86. Should either option 2 or 3 be chosen, it would be advisable to rename the account from the current 'Air Emission Accounts (AEA)' to 'Air Emissions and Removals Accounts (AERA)'. The proposed designation may more accurately reflect the new nature of the accounts: whereas previously the focus was solely on emissions, the SEEA CF update would encompass both emissions and removals.
87. The scope of the AEA includes both biogenic and non-biogenic carbon emissions. It is highly policy relevant to distinguish between the two. The text of the SEEA CF should further clarify this and recommend how to record this in the AEA. Furthermore, the discussion on the use of wood products prompts the opportunity for SEEA 2028 to clarify that emissions resulting from wood combustion should be allocated based not on the location of the combustion, but rather on the residency of the economic agent responsible for burning the wood.

4 Recommendations on conceptual treatments

→ *To be done after consultation*

- Propose recommendations to address the issue (based on the options described under section 3)
- List the sections/paragraphs of the SEEA CF that need to change or where additional content is required
- Where possible provide proposed text for inclusion in the revised SEEA CF

5 Other considerations in advancing the issue

→ *To be done*

- Describe the existing compliance 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)
- Describe options for testing the recommended approaches
- 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 – potentially in relation to other statistical standards – e.g. SNA

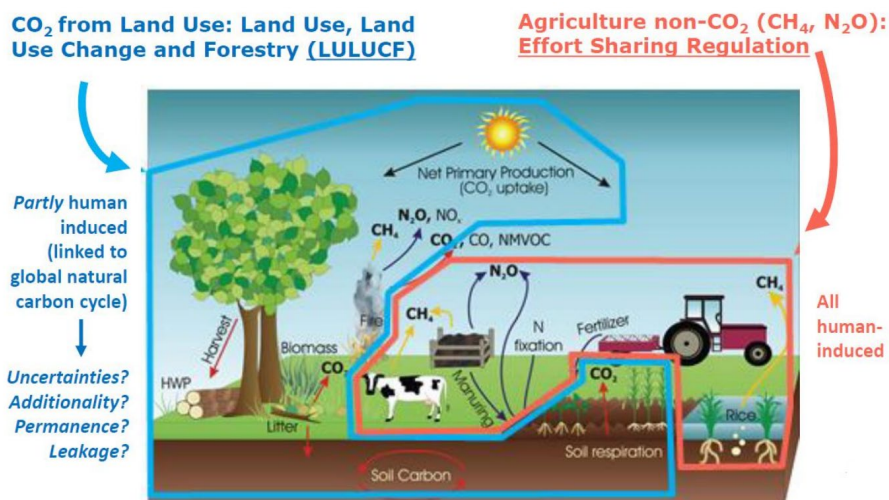
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Annex: What is LULUCF?

Land use, Land-use Change, and Forestry (LULUCF) is defined by the UNFCCC as a **greenhouse gas inventory sector that covers emissions and removals of greenhouse gases resulting from direct human-induced land use, land use change and forestry activities** (UNFCCC, 2012). It thus covers emissions and removals of greenhouse gases (CO_2 , N_2O and CH_4) resulting from direct human-induced land use (agriculture, forestry, wetlands, settlements etc.), land-use change, and forestry activities.

The LULUCF sector is different from the other sectors defined by the UNFCCC as it a) includes emissions from biomass (all other sectors exclude biomass related flows as they are short cyclic), and b) includes not only emissions but also removals of carbon from the atmosphere. The LULUCF sector also is closely connected to the Agriculture sector. The figure below explains the scope difference between the two sectors.



UNFCCC greenhouse gas emission inventories distinguish the following sub-sectors of LULUCF (see also table below): forest land, cropland, grassland, wetlands, settlements, other land, harvested wood products, other land use, land use change, and forestry, managed soils - indirect N_2O emissions. These subsectors thus represent some key land use categories (as defined by the UNFCCC) plus some extra categories such as harvested wood products etc.

Greenhouse gas emissions by LULUCF sector; EU 1990-2019, million tonnes CO₂-equivalents

CRF code	CRF label	1990	2000	2010	2019
CRF4	Land use, land use change, and forestry (LULUCF)	-211	-306	-315	-249
CRF4A	Forest land	-335	-397	-405	-329
CRF4A0	Drainage and rewetting and other management of organic and mineral soils related to forest land - emissions and removals	7	7	6	6
CRF4A1	Unconverted forest land	-304	-357	-356	-297
CRF4A2	Land converted to forest land	-38	-47	-55	-39
CRF4B	Cropland	66	59	51	41
CRF4B0	Drainage and rewetting and other management of organic and mineral soils related to cropland - emissions and removals	5	4	4	4
CRF4B1	Unconverted cropland	23	19	7	3
CRF4B2	Land converted to cropland	38	36	40	34
CRF4C	Grassland	34	24	14	13
CRF4C0	Drainage and rewetting and other management of organic and mineral soils related to grassland - emissions and removals	3	3	3	3
CRF4C1	Unconverted grassland	49	42	35	31
CRF4C2	Land converted to grassland	-17	-21	-24	-21
CRF4D	Wetlands	13	13	17	17
CRF4D0	Drainage and rewetting and other management of organic and mineral soils related to wetlands - emissions and removals	2	2	2	2
CRF4D1	Unconverted wetlands	8	9	10	10
CRF4D2	Land converted to wetlands	2	3	5	5
CRF4E	Settlements	35	37	42	44
CRF4E0	Biomass burning in settlements	0	0	0	0
CRF4E1	Unconverted settlements	2	2	2	2
CRF4E2	Land converted to settlements	33	35	40	42
CRF4F	Other land	4	1	1	2
CRF4F2	Land converted to other land	3	0	0	0
CRF4F3	Nitrogen mineralization and immobilization in other land - direct	1	1	1	1
CRF4F4	N ₂ O emissions	0	0	0	0
CRF4G	Harvested wood products	-29	-46	-38	-38
CRF4H	Other land use, land use change, and forestry	0	1	0	0
CRF4Z	Managed soils - indirect N ₂ O emissions	1	1	1	1

Source: EEA re-published by Eurostat (env_air_gge)

As can also be deduced from the table above, accounting for the LULUCF emissions and removals is quite complex. Basically, we can summarize it as follows:

- 1) Emissions and absorptions linked to **land use**, including
 - Growth of trees, leading to absorption of carbon (carbon sequestration)
 - Biomass mortality, wood removal in forests, forest fires, leading to carbon emissions
 - Impacts of changes in agricultural practices on cultivated soils, etc.
- 2) Emissions and absorptions linked to **changes in land use**, including
 - Deforestation,
 - Afforestation,
 - Soil artificialisation, etc.
- 3) **Harvested Wood Products** (HWPs). HWPs are wood-based materials harvested from forests, which are used for products such as furniture, plywood, paper and paper-like products, or for energy. It is assumed that all carbon removed in wood and other biomass from forests is oxidized and emitted to the atmosphere in the year of removal.