CHAPTER 7.

Land use change emissions

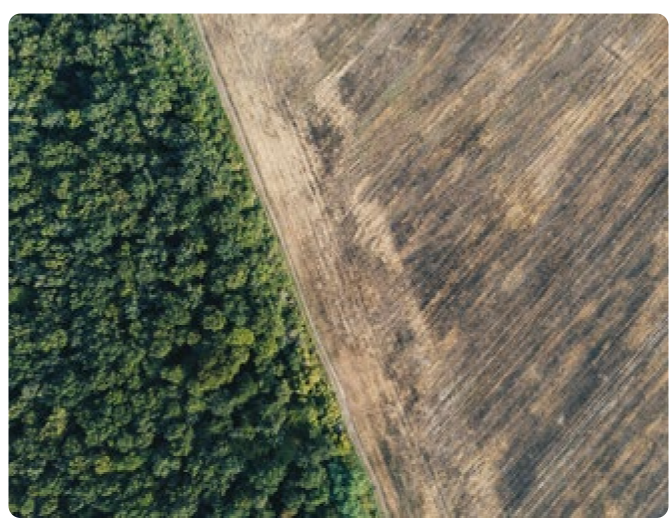
This chapter provides requirements and recommendations on accounting for and reporting GHG emissions due to recent land use change (LUC) in a company's GHG inventory. LUC emissions include emissions due to deforestation or other types of conversion between land use categories or subcategories that have occurred in recent years.

7.1 Overview

Emissions from LUC are any release of GHG emissions due to a change in land use from one land use category or subcategory to another (see Glossary and *Guidance* for land use category definitions). Subcategory land use change is a change between subcategories within a land use category, such as conversion from natural forest to plantation forest (see Requirement 11 below). LUC emissions are calculated based on the total land carbon stock decrease across all land ecosystem carbon pools and other GHG emissions due to land use change. Removals due to LUC (e.g., reforestation or afforestation) are accounted for as "land management CO_2 removals" separately from "land use change emissions" (see Chapter 13).

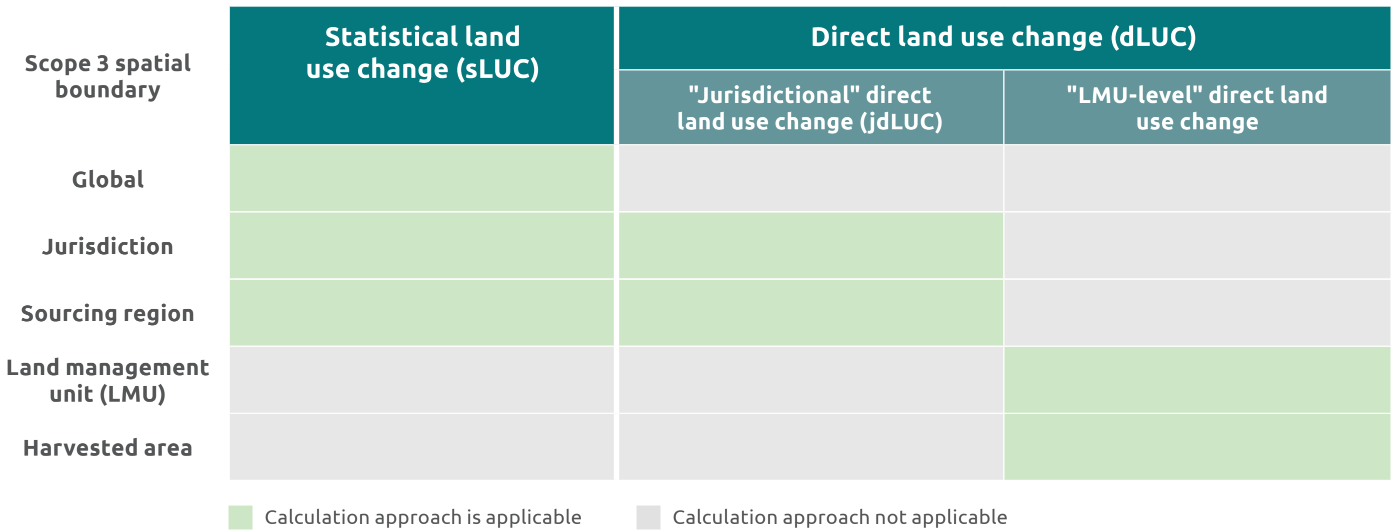
LUC emissions are generally released to the atmosphere quickly following conversion, but a land use conversion can enable continuous agricultural production, not only during the following year but for many years, depending on the production system. LUC emissions from conversion are assigned to all products grown during the LUC assessment period (20 years or greater), not only to the production that occurred in the year the LUC occurred. Using a method called linear amortization, products grown closer in time to the year of conversion are weighted more heavily (i.e., assigned greater LUC emissions) than products grown more distant in time from the year of conversion.

Companies account for LUC emissions using the "LMU-level" direct land use change (dLUC) calculation approach on lands they own or control, or those LMUs to which they have complete traceability in their value chain (Figure and Table 7.1). Companies account for land use change emissions using the "jurisdictional" dLUC calculation approach or the statistical land use change (sLUC) calculation approach when specific sourcing lands are unknown (Figure and Table 7.1). Companies can use sLUC emission factors provided by third-party databases, but must verify that the sLUC emission factor applies the product expansion allocation method and satisfies other requirements set forth in Requirement 10 below.



Companies that raise livestock or have animal products in their value chain must follow the LUC accounting Requirement 10.1. Companies that own or control water reservoirs or have water reservoirs in their value chain (e.g., by purchasing electricity from hydropower) must follow the LUC accounting Requirement 10.2.

Figure 7.1 Land use change emissions calculation approaches based on value chain traceability



7.2 Requirements

7.2.1 Accounting requirements

REQUIREMENT 10:

Land use change emissions accounting

Companies **shall** account for land use change emissions according to the following requirements:

- **GHG emissions**: Companies **shall** account for CO_2, CH_4, and N_2O emissions caused by LUC.
- **Carbon pools**: Companies **shall** account for LUC CO_2 emissions based on the total land carbon stock decrease across all land carbon pools (i.e., above-ground and below-ground biomass, dead organic matter, and soil carbon pools).
  - When LUC results in net removals or removals following an initial conversion that resulted in emissions, companies **shall** first account for the gross LUC emissions of the initial land use change, and then may separately account for the land management net CO_2 removals of the subsequent land use following the removals accounting requirements set forth in Chapters 12 and 13.
- **Time period**: Companies **shall** account for LUC emissions that occurred within the LUC assessment period.
  - For annual crops or other land-based products or services with a cultivation cycle or rotation period less than or equal to 20 years, the LUC assessment period is 20 years. The LUC assessment period is prior to and includes the reporting year (e.g., 2001–20 assessment period for 2020 reporting year).
  - For land-based products with a cultivation cycle or rotation period more than 20 years, the length of that cycle or period is used as the LUC assessment period (prior to and inclusive of the reporting year).
  - Companies **shall** allocate the LUC emissions to each year in the LUC assessment period using linear amortization according to the formula set forth in Section 7.5 of the *Guidance* or **shall** disclose and provide justification if another time amortization method is used (e.g., equal amortization) in the specific circumstances set forth in Table 7.1 (see "jurisdictional dLUC, scenario B").

- **Spatial boundary**: Companies **shall** account for scope 1 LUC emissions on lands they own or control and scope 3 LUC emissions on lands in their value chain. Requirements for defining the lands included in the scope 1 and 3 spatial boundaries are set forth in Requirement 5.
    - For clarification on how Requirements 5 and 6 are satisfied when accounting using sLUC or dLUC calculation approaches, see Section 7.4 in the *Guidance*.
- **Calculation approach**: Companies **shall** use either a direct land use change (dLUC, either "LMU-level" or "jurisdictional" dLUC approach) or statistical land use change (sLUC) calculation approach for a given product type by sourcing jurisdiction (see also the "Recommendation for a consistent calculation approach" in Section 7.3).
    - Companies **shall** select the most accurate calculation approach that their data availability and value chain traceability allow. The selected approach **should** follow the hierarchy of calculation approaches for land use change accounting in Table 7.1.
    - Companies using the sLUC calculation approach **shall** apply the product expansion allocation method or **shall** provide justification if the shared responsibility allocation method is used in the specific circumstance set forth in Section 7.3 (see "sLUC allocation method exception").
- **Re-baselining**: Companies **shall** re-baseline when there is a change in:
    - the LUC emissions calculation approach (i.e., between sLUC and dLUC calculation approaches); or
    - the data/methods used within the calculation approach (e.g., a change from non-spatialized to spatialized crop statistics data) for a given product by sourcing jurisdiction.

See Requirement 29 for details regarding base year or period recalculations.

Specific cases

REQUIREMENT 10.1
Animal products:

Companies that raise livestock or have animal products in their value chain shall account for land use change emissions on both lands used for livestock grazing and croplands used for feed production consumed by the livestock over the animal's life cycle.

REQUIREMENT 10.2
Water reservoir emissions:

Companies that own or control water reservoirs, companies that purchase electricity generated from hydropower at water reservoirs, companies that produce or purchase agricultural products irrigated with water stored in water reservoirs, or companies that otherwise have water reservoirs in their value chain **shall** account and report emissions from water reservoirs as land use change emissions.

- **Hydropower-associated emissions**: Companies acquiring or purchasing electricity generated from hydropower **shall** account for emissions from the water reservoir as LUC emissions in scope 3, category 3.
- **Assessment period for CO_2**: CO_2 emissions from land converted to a water reservoir **should** be accounted for during the first 20 years after the LUC (i.e., the creation of the water reservoir).

- **Assessment period for CH_4**: CH_4 emissions from land converted to a water reservoir **should** be accounted for during the first 100 years after the LUC (i.e., the creation of the water reservoir).
- **Hierarchy of methods**: Companies **should** account for LUC emissions from water reservoirs using the following hierarchy of methods: 1) on-site measurements; 2) modeling tools (e.g., G-Res tool); and 3) IPCC emission factors. If using on-site measurements or modeling tools, companies **should** account using a 5- to 10-year average.

REQUIREMENT 11:
Subcategory land use change emissions accounting[1]

Companies **shall** account for subcategory land use change emissions according to the following requirements:

- **GHG emissions, carbon pools, time period, spatial boundary, and calculation approach**: Companies **shall** follow the requirements set forth in Requirement 10 when accounting for subcategory land use change emissions.
- **Forest land subcategory land use change**: Companies **shall** account for forest subcategory land use change emissions if:
  - There is clearance of natural forest or severe and sustained degradation[2] of natural forest within the LUC assessment period; or
  - There is replacement of natural forest with a plantation forest or with tree crops (e.g., fruit tree plantations, oil palm plantations, olive orchards, and agroforestry systems when crops are grown under tree cover).[3]

    Plantation forest: Defined as a forest predominantly (i.e., > 50 percent of growing stock at maturity) composed of trees established through planting and/or deliberate seeding that is intensively managed and meets all the following criteria at planting and stand maturity: one or two species, even age class, and regular spacing.[4]
- **Grassland subcategory land use change**: Companies **shall** account for grassland subcategory land use change emissions when there is:
  - Conversion of natural grasslands (e.g., savannahs, shrublands, and other land cover that falls below the forest land threshold) to intensively managed grasslands (e.g., improved or planted pastures or grazing land characterized by severe and sustained degradation).[2]
- **Wetland subcategory land use change**: Companies **shall** account for wetland subcategory land use change emissions when there is:
  - Conversion (i.e., drainage) of natural wetlands to productive wetlands. Note: This conversion is treated as a land use change, not a subcategory land use change, in the IPCC classification system.

7.2.2 Reporting requirements

Reporting requirements for land use change emissions

Companies **shall** report:

- Land use change and subcategory land use change emissions in the "land use change emissions" accounting subcategory under "land emissions" in the physical GHG inventory.

Companies **shall** disclose in their GHG report the following information related to land use change and subcategory land use change emissions:

- **Calculation approach**: Whether a dLUC or sLUC calculation approach was used to account for scope 1 and scope 3 land use change emissions (see "Recommendation for a consistent calculation approach" in Recommendations), with justification regarding accuracy and data availability for the approach used.
  - If sLUC metrics were used, whether an alternative to the product expansion allocation method was used to calculate sLUC emissions; if so, provide justification for the approach used (see "sLUC allocation method exception" in Section 7.3).
  - If dLUC metrics were used, the allocation method(s) used for land use change emissions and information on how the company demonstrated traceability to relevant land areas within their value chain for scope 3 land use change emissions.
- **Time period**: The length of the LUC assessment period(s) used and how it relates to the relevant cultivation cycle or rotation period, and whether an alternative method to linear amortization was used to distribute land use change emissions over the LUC assessment period (see "jurisdictional dLUC, scenario B" in Table 7.1). If an alternative to linear amortization was used, justify the approach taken.
- **Animal products and reservoir emissions**: Whether reported land use change emissions include LUC emissions attributable to animal products and/or water reservoirs. If these activities are not relevant to the reporting company, provide justification.

7.3 Recommendations

Choosing a direct or statistical land use change calculation approach

Recommendation for a consistent calculation approach:

Companies **should** determine a single calculation approach for: 1) their scope 1 LUC emissions, and 2) each land use change-related product type by sourcing jurisdiction within their scope 3 LUC emissions. They **may** use both dLUC and sLUC calculation approaches across their inventory, but **should** not use two approaches for a given product type by sourcing jurisdiction. Note: "LMU-level" and "jurisdictional" dLUC calculation approaches are two types of dLUC calculation approaches and may be used for the same product type.

- **LUC calculation approach exception for livestock and other systems**: Companies **may** use two different LUC calculation approaches to complete the accounting for LUC emissions attributable to lands on which the primary product is produced and LUC emissions attributable to lands on which products that are inputs into the production of that primary product are produced (e.g., a dLUC approach for land on which animals are grazed, and an sLUC approach for land where supplemental animal feed is produced).

Recommendations for selecting a calculation approach:

Companies **should** follow the hierarchy of approaches in Table 7.1, as explained below:

"LMU-level" direct land use change (dLUC) calculation approach: Companies **should** use the LMU-level dLUC calculation approach (see Table 7.1) to account for LUC emissions on:

- All lands owned or controlled by the company
- All lands in LMUs the reporting company sources from, and to which the company has complete traceability, following Requirement 8

"Jurisdictional" direct land use change (dLUC) calculation approach: Companies **should** use the jurisdictional dLUC calculation approach (see Table 7.1) to account for LUC emissions when companies have traceability to a sourcing region or jurisdiction, and adequate spatial data exists to estimate "jurisdictional" dLUC emissions on all attributable productive lands (see Requirement 6) in the sourcing region or jurisdiction the company sources from (i.e., to spatially locate LUC that occurred in the LUC assessment period on all attributable productive agricultural lands).

- This approach requires spatial data, including a complete crop extent map of all LMUs where the sourced product was produced in the jurisdiction or sourcing region in the reporting year (i.e., all attributable productive agricultural lands), and jurisdictional land use/land cover maps for all or some years in the LUC assessment period, ideally including the first and last year in the LUC assessment period. See the *Guidance* for how to implement a "jurisdictional" dLUC approach.
- Because the two calculation approaches are methodologically compatible, companies can combine "jurisdictional" and "LMU-level" dLUC calculation approaches to complete the LUC accounting for a product type by sourcing jurisdiction. Companies **should** use LMU-level dLUC emission factors for any LMUs the reporting company sources from and has complete traceability to, following Requirement 8.

Statistical land use change (sLUC) calculation approach: Companies **should** use the sLUC calculation approach (see Table 7.1) to account for LUC emissions on all lands in the jurisdiction or sourcing region when the most granular level of traceability the company has is to that jurisdiction or sourcing region and where only statistical data is available (i.e., where a spatial, *non*-statistical crop extent map is not available in the reporting year to implement the "jurisdictional" dLUC approach). See the *Guidance* for how to implement an sLUC calculation approach.

Recommendations for transitioning from sLUC to dLUC calculation approaches:

As companies transition from statistical to spatially explicit data to estimate LUC emissions (i.e., from an sLUC to a jurisdictional dLUC approach, see Table 7.1), companies **should** follow the guidance below. Note that companies must also satisfy the re-baselining requirement in Requirement 10.

- **Moving from sLUC to dLUC calculation approaches**: If a company has data to estimate LUC emissions using the jurisdictional dLUC calculation approach for 80 percent or more of their key land use change-related commodity volumes, but adequate data is not available to estimate jurisdictional dLUC emissions for the remaining 20 percent of commodity volumes, to complete the accounting, companies **may** use spatially explicit statistical data following the sLUC calculation approach to estimate the remaining LUC emissions. When using spatially explicit data to estimate sLUC emissions in such cases, companies **should** prioritize using the product expansion allocation method, followed by the shared responsibility allocation method, depending on data availability.

- **sLUC allocation method exception**: As an exception to Requirement 10, companies **may** use the shared responsibility allocation method if spatially explicit statistical data is used to estimate sLUC emissions, but such data does not enable the consistent representation over time needed to apply the product expansion allocation method.

Table 7.1 Hierarchy of calculation approaches for land use change emissions accounting

Priority based on accuracy	Calculation approach	Traceability requirement	Spatial data requirement	Amortization method
Most accurate	**Land management unit (LMU)-level direct land use change (dLUC):** Use LMU-level dLUC emissions data.	Complete traceability to LMUs in the reporting year.	Jurisdictional or sourcing region area land use/land cover map for all or most years (should include the first and last year in the LUC assessment period).	Linear
Intermediate accuracy	**Jurisdictional dLUC:** Use jurisdictional (i.e., national or subnational) dLUC emission factors where companies do not have complete traceability to all LMUs and complete jurisdiction-level land use maps are available for all (Scenario A) or some (Scenario B) years (see “selecting a land use change approach” in 7.3). If applicable, can combine with the use of LMU-level dLUC emission factors where companies have complete traceability to the LMU.	Less than complete traceability to LMUs in the reporting year.	**Scenario A**: Jurisdictional or sourcing region area land use/land cover map for all or most years in the LUC assessment period (should include the first and last years in the assessment period). Crop-specific map for attributable productive agricultural land in the jurisdiction or sourcing region in the reporting year.	**Scenario A**: Linear
			Scenario B: Jurisdictional or sourcing region area land use/land cover map for some years in the LUC assessment period (should include the first and last year in the assessment period). Crop-specific map for attributable productive agricultural land in the jurisdiction or sourcing region in the reporting year.	**Scenario B**: *Linear* (if > two years of land use/land cover maps available in LUC assessment period). *Equal* (if only two years of land use/land cover maps in the LUC assessment period, e.g., the first and last year).
Least accurate	**Statistical land use change (sLUC):** Use national, subnational, or sourcing region sLUC emission factors only.	Less than complete traceability to LMUs in the reporting year.	Only statistical data available[a]	Linear

Note: a. Note that a “spatial” sLUC approach is possible if statistical data is spatially distributed (i.e., with a predictive crop distribution model). If a company has a spatial, non-statistical crop extent map for the relevant commodity in the reporting year, use a jurisdictional dLUC approach.

7.4 Guidance on the requirements and recommendations

7.4.1 Classifying land use change and subcategory land use change

Following IPCC definitions, this *Standard* defines land use based on six overarching land use categories and also defines certain subcategories within these major land use categories. To review these category definitions, see Section 3.4.2.

Land use change (LUC) emissions are emissions (primarily from carbon stock losses) due to recent land conversion from one land use category or subcategory to another (Figure 7.2), such as the CO_2 released from native carbon stocks when clearing forests or grasslands, or draining wetlands for agricultural production on croplands. Subcategory LUC is a change between subcategories within a land use category, such as conversion from natural grassland to productive grassland, or natural forest to plantation forest. Complete and accurate accounting for LUC emissions depends on the accurate and consistent classification of land use and subcategory land use types.

Classifying subcategory land use changes

This *Standard* recognizes the following types of subcategory land use changes:

Forest subcategory land use change: Forest subcategory land use change occurs when there is a conversion between natural and planted (e.g., plantation) forest land uses. As set forth in Requirement 11, forest subcategory land use change occurs when:

- There is clearance of natural forest or severe and sustained degradation of natural forest[5] within the assessment period; or
- There is a replacement of natural forest[6] with a plantation forest.

Examples of forest subcategory conversion events include:

- Clearing or harvesting of a natural forest and planting non-native tree species or monocultures
- Conversion of natural forest to a productive agroforestry system with planted species and a forest structure that consistently meets established forest land thresholds
- Forest management practices that result in severe and sustained degradation that significantly alters forest species composition, structure, and function

Note that the conversion of forest land (natural or plantation) to tree crops (e.g., fruit tree plantations, oil palm plantations, olive orchards, and agroforestry systems where crops are grown under tree cover) constitutes a forest to cropland land use change.

Grassland subcategory land use change: As set forth in Requirement 11, grassland subcategory land use change occurs when there is conversion of natural grasslands to productive grasslands (e.g., improved or planted pastures).[7]

Examples of grassland subcategory conversion events include:

- Conversion of natural grasslands to productive grasslands, such as pastures planted with non-native forage
- Clearing of natural woodlands, shrublands, or savannahs that do not meet forest land thresholds for grazing livestock

Wetland subcategory land use change: As set forth in Requirement 11, wetland subcategory land use change occurs when there is conversion (i.e., drainage or other disturbance) of natural wetlands to productive wetlands. Examples of wetland subcategory conversion events include:

- Drainage or other disturbance of natural wetlands for peat extraction or other human activities
- Conversion of natural wetlands to aquaculture production systems (e.g., shrimp farms)

When determining whether to account for emissions due to anthropogenic activities on wetlands or other lands with wetland soils, either as LUC emissions (Chapter 7), land management net biogenic CO_2 emissions (Chapter 9), or land management production emissions (Chapter 10), companies should refer to the IPCC's *2019 Refinement*[8] together with the *2013 Wetlands Supplement*[9] to determine whether land management activities represent a land use change or management on land that remains in the same land use category. Note that land used for rice cultivation is considered cropland. Lands that are flooded by human activities (e.g., water reservoirs, canals, drainage ditches, etc.) are considered wetlands. To account for LUC emissions from water reservoirs, see Requirement 10.2 in the *Standard* and Section 7.5.3.4.

Peat extraction/mining and paludiculture occur on wetlands where the water table is changed (e.g., by draining or through river diversion) by human activities. Draining, rewetting, burning, and other disturbances of organic soils (e.g., peatlands) have particularly high emissions; when accounting for these emissions either as LUC emissions or land management net biogenic CO_2 emissions, companies should refer to the IPCC's *2019 Refinement* together with the *2013 Wetlands Supplement*.

Figure 7.2 Land use change categories and subcategories

Pre-conversion land use category \ *Post-conversion land use category*	Forest land	Grassland	Cropland	Wetland	Settlement	Other land
Forest land	F → F	F → G	F → C	F → W	F → S	F → O
Grassland	G → F	G → G	G → C	G → W	G → S	G → O
Cropland	C → F	C → G	C → C	C → W	C → S	C → O
Wetland	W → F	W → G	W → C	W → W	W → S	W → O
Settlement	S → F	S → G	S → C	S → W	S → S	S → O
Other land	O → F	O → G	O → C	O → W	O → S	O → O

Forest subcategories	Natural forest	Plantation forest
Natural forest	NF → NF	NF → PF
Plantantion forest	PF → NF	PF → PF

Grassland and wetland subcategories	Natural	Productive
Natural	N → N	N → P
Productive	P → N	P → P

Land use change that typically leads to carbon stock losses

Land use change that typically leads to carbon stock gains following an initial conversion that resulted in gross carbon stock losses[b]

Forest subcategories

Grassland and wetland subcategories

Notes: a. For definitions of land uses and natural and productive subcategory land uses, see Section 3.4.2; b. As set forth in Requirement 10, some land use changes may result in net removals or removals following an initial conversion that resulted in emissions. In such cases, companies must first account for the gross LUC emissions of the initial land use change, and then may separately account for the land management net CO_2 removals occurring within the subsequent land use following the removals accounting requirements set forth in Chapters 12 and 13.

Source: Adapted from IPCC (2003) and IPCC (2019a).

Land management net CO_2 removals following land use conversion

Some land use changes can result in higher land carbon stocks in the post-conversion land use (e.g., afforestation, conversion of croplands to grasslands). Net land carbon stock gains can occur gradually following a land use change and may be accounted for as land management CO_2 removals based on annual net land carbon stock increases occurring in the reporting year. Despite any gradual carbon stock gains (or losses) over time, post-conversion, gross land carbon stock losses and associated LUC emissions still occur from the initial conversion event (e.g., initial timber harvest prior to establishing a forest plantation, mechanical clearing or fire used to clear land for agricultural production). When accounting for LUC that eventually leads to higher land carbon stocks in the post-conversion land use following an initial conversion, companies must first account for the gross

LUC emissions attributable to the initial conversion event, as set forth in Requirement 10 and calculation guidance in Section 7.5. Companies can then separately account for any land management CO_2 removals attributable to the subsequent land use, following the removals requirements and calculation guidance in Chapters 12 and 13.

This approach ensures separate accounting of LUC emissions and CO_2 removals from post-conversion land management practices during the assessment period. Note that post-conversion land management practices that lead to net carbon stock losses are accounted for as land management net biogenic CO_2 emissions.

For example, conversion between forest subcategory land uses (i.e., natural and planted forests) can eventually lead to net gains or losses in total terrestrial carbon stocks following the gross emissions due to the initial subcategory LUC event. When accounting for forest subcategory LUC emissions, a company must first account for the gross LUC emissions of the initial forest subcategory land use change (following the requirements and calculation guidance in Chapter 7), and then may separately account for the land management CO_2 removals of the subsequent subcategory land use (following the removals requirements and calculation guidance in Chapters 12 and 13).

7.4.2 Relationship between land use change metrics, land use, and land carbon leakage

To account for a company's full contribution to emissions from agricultural land expansion, this *Standard* requires multiple "land use change-related" metrics (see Box 7.1). The land use change (LUC) metrics outlined here in Chapter 7 (direct and statistical land use change emissions) measure annual emissions from gross, recent expansion of agricultural land due to conversion of lands in a company's operations or value chain.

A company sourcing agricultural products may reduce its LUC emissions by switching to suppliers with less recent conversion in their operations, but will continue to contribute to the overall global demand for land use. Similarly, companies that account for and report sLUC emissions may exit a landscape entirely to avoid increasing responsibility for sLUC emissions. However, shifting sourcing to reduce LUC emissions in the inventory without reducing land use can shift, rather than lessen, a company's contribution to overall global land demands and land conversion pressure (i.e., such shifts may have no net climate benefits). Therefore, the total quantity of agricultural land used by a company in its operations or value chain, regardless of when that agricultural land was cleared, also contributes to global land pressure that leads to net global land use change and LUC emissions.

A full accounting of a company's contribution to global land pressures that lead to land use change includes a measurement of recent LUC emissions in the company's inventory boundary (Chapter 7), as well as the company's total contribution to global agricultural land use (Chapter 8) and land use change that occurs on land beyond the company's operations and value chain, i.e., land carbon leakage (Chapter 8). Instead of switching suppliers or abandoning sourcing areas or regions altogether, companies are encouraged to work with existing suppliers to improve land use efficiency and reduce global land demands (i.e., by setting land use and land carbon leakage targets) and to engage in broader sourcing areas to reduce gross LUC emissions and increase land use efficiency both within and beyond their own supply chains.

7.4.3 Land use change emissions calculation approaches and spatial boundaries

Calculation approaches

This *Standard* sets forth two general calculation approaches to account for LUC emissions: the direct land use change (dLUC) calculation approach (which includes both an “LMU-level” dLUC and “jurisdictional” dLUC approach) and the statistical land use change (sLUC) calculation approach (Tables 7.1 and 7.2). The two general calculation approaches (dLUC and sLUC) are compared in Table 7.3.

Table 7.2 Land use change emission calculation approaches

Calculation approach		Definition	
Direct land use change (dLUC)	**LMU-level dLUC**	A calculation approach that uses primary data to quantify emissions (primarily from carbon stock losses) due to land conversion during the assessment period directly on an area of land with a known land use related to the reporting company’s operation or value chain.	An LMU-level dLUC approach uses primary data specific to a land management unit (LMU).
	Jurisdictional dLUC		A jurisdictional dLUC (jdLUC) approach uses regional or national data of known land uses.
Statistical land use change (sLUC)		A calculation approach used to calculate emissions (primarily from carbon stock losses) due to LUC during the assessment period within a sourcing region or jurisdiction, that assigns responsibility for LUC emissions in the relevant boundary to products produced in that region using a statistical proxy; used in situations of limited product traceability (and when data to perform a jdLUC approach is not available).	

As set forth in Requirement 10, when accounting for LUC emissions, a company must use either a direct land use change (dLUC, either “LMU-level” or “jurisdictional” dLUC approach) or statistical land use change (sLUC) calculation approach, for a given product type by sourcing jurisdiction. In other words, companies may use either or both dLUC and sLUC calculation approaches across their inventory, but not combine the two general approaches when accounting for the same product type by jurisdiction. Note, however, that “LMU-level” and “jurisdictional” dLUC calculation approaches are two types of dLUC calculation approaches, and may be used for the same product type.

For example, a company could apply a jdLUC calculation approach to account for LUC emissions from all the cocoa they source from Ghana and Côte d’Ivoire, but apply an sLUC approach to account for LUC emissions from the cocoa they source from other countries and for other agricultural products they source. Companies should determine a single calculation approach for their scope 1 LUC emissions, and each LUC-related product type by sourcing jurisdiction within their scope 3 LUC emissions.

For further guidance on choosing a LUC emissions calculation approach and the data needed to implement the approach, see Section 7.5. When choosing a LUC calculation approach, a company should follow the hierarchy of calculation approaches for LUC emissions accounting in Table 7.1 in the *Standard*. Companies must apply the most accurate calculation approach that their data availability and value chain traceability allow. As data availability, quality, and traceability improve, companies should work towards using a higher-accuracy calculation approach over time.

Table 7.3 Comparison of direct land use change (dLUC) and statistical land use change (sLUC) calculation approaches

Calculation approach		Spatial boundary/ lands included in the spatial boundary	What it measures	Benefits	Challenges
Direct land use change (dLUC)	**LMU-level dLUC**	Land management unit (LMU)-level scope 3 spatial boundary, including all land within the LMU boundary Scope 1 spatial boundary, including all land owned/ controlled by the reporting company	LUC emissions due to recent land conversion occurring directly on the land a company owns/ controls, or on specific lands where a sourced product was produced	Most accurate approach; easy to communicate	More data-intensive and requires full traceability to land management units
	Jurisdictional dLUC	Jurisdiction or sourcing region scope 3 spatial boundary, including all *attributable productive lands* for the relevant agricultural product within the scope 3 spatial boundary	LUC emissions due to recent land conversion occurring directly on attributable productive lands for a given agricultural product in the relevant spatial boundary	Increased accuracy relative to sLUC; not as data-intensive as LMU-level dLUC	Complete spatial land use and crop-extent data for the relevant agricultural product within the jurisdiction or sourcing region is required (see Table 7.8)
Statistical land use change (sLUC)		Sourcing region, jurisdiction, or broader scope 3 spatial boundary, including *all* productive agricultural lands within the scope 3 spatial boundary	LUC emissions due to recent land conversion on lands in the relevant spatial boundary, allocated across all agricultural products produced in that boundary, using production statistics as a proxy	Relatively easy to calculate; production statistics are readily available from secondary data sources	Least accurate approach

Note that, as set forth in Requirement 10 and Requirement 28, changing the calculation approach (i.e., between sLUC and dLUC calculation approaches) requires re-baselining to enable consistent LUC emissions tracking over time. A change in the data and methods used within the *same* calculation approach (e.g., a change from non-spatial to spatial data in an sLUC approach) also requires re-baselining. For more guidance on base year recalculation, see Chapter 17.

dLUC and sLUC are both designed to account for gross LUC emissions, but the information that these methods provide informs and enables different types of mitigation options. If a company uses a dLUC calculation approach to account for scope 3 LUC emissions in the physical GHG inventory, it may also account for LUC emissions using an sLUC calculation approach, but it must report such values separately from the physical GHG inventory. Additionally quantifying and separately reporting sLUC emissions can help capture information about wider LUC impacts in the jurisdictions or sourcing regions where the reporting company sources land-based products. Because other actors beyond the reporting company influence the sLUC metric, impacts of actions beyond those within the reporting company's immediate supply chain can be captured when applying the sLUC calculation approach. Quantifying and reporting both dLUC and sLUC emissions can therefore highlight actions that companies can influence directly and those that correspond to landscape-level or jurisdictional policy solutions.

Spatial boundaries

Figure 7.1 provides an overview of the LUC emissions calculation approach that companies use when setting different types of spatial boundaries. When accounting for scope 1 LUC emissions, companies will in most instances use an LMU-level dLUC calculation approach.

When applying an sLUC calculation approach, *all* productive agricultural lands are included in the relevant scope 3 spatial boundary. For example, if a company has traceability to Argentina for the soybeans it sources, and the company applies an sLUC calculation approach, all productive agricultural land is included within the scope 3 spatial boundary, including both land that produces soybean and all other agricultural land in Argentina.

If the reporting company instead has the data needed to apply a jurisdictional dLUC calculation approach, all *attributable* productive lands are included in the relevant jurisdiction scope 3 spatial boundary. In this case, building on the previous example, all land that produces soybeans in Argentina in the reporting year is included in the jurisdictional scope 3 spatial boundary, but all other agricultural land in Argentina is excluded.

If the reporting company refines its traceability to specific LMUs and applies an LMU-level dLUC calculation approach, all land within the relevant LMUs is included in the LMU scope 3 spatial boundary. In this case, building on the previous example, the reporting company would include all land within the LMU boundary, including, but not limited to, all of the cropland within the LMUs that the company has traceability to. If some of those LMUs produce multiple crops (e.g., soy and maize) the reporting company must allocate LUC emissions to the relevant crops within the LMU following the allocation recommendations in Section 6.3.

If the reporting company refines its traceability to specific fields (i.e., harvested areas) within LMUs and applies an LMU-level dLUC-calculation approach, all land in the harvested area is included in the harvested area scope 3 spatial boundary. In this case, building on the previous example, the reporting company would include all land within the relevant soy fields that the company has traceability to.

7.4.4 Greenhouse gases and carbon pools in land use change emissions accounting

Greenhouse gases

As set forth in Requirement 10, a company must account for all GHGs due to LUC, including CO_2, N_2O, and CH_4. CO_2 typically dominates LUC emissions,[10] but emissions of CH_4 and N_2O can also result from LUC. For example, the following LUC situations can cause LUC emissions of all three GHGs:

- Burning vegetation during a LUC event, releasing CO_2, CH_4, and N_2O emissions.
- Losses of soil carbon during a LUC event result in emissions of CO_2. Soil disturbance during such an event can also lead to mineralization of nitrogen in soil organic matter, generating N_2O emissions.
- Peatland drainage during a LUC event oxidizes soil organic matter, which also results in large emissions of CO_2 and N_2O. (Note that, in a shift from anaerobic to aerobic conditions, peatland drainage also reduces some CH_4 emissions).

Carbon pools

As set forth in Requirement 10, a company must account for CO_2 emissions due to LUC based on the total gross land carbon stock decreases across all land-based carbon pools, including the biomass (above- and below-ground) carbon pool, dead organic matter carbon pool, and soil carbon pool. LUC events typically impact all land-based carbon pools; the relative size of impact on each land-based carbon pool depends on the LUC event and the ecosystem in which the event occurs.

7.4.5 LUC assessment period and amortization methods

LUC assessment period

The required default LUC assessment period is 20 years, prior to and inclusive of the reporting year (see Table 7.4). For example, if the reporting year is 2025, the reporting company is partially responsible for any LUC emissions that occurred on the land they own or operate or land in their value chain during the period 2006–2025. The default 20-year LUC assessment period applies to annual and perennial crops, livestock, and other products with a cultivation cycle of 20 years or less, including multi-cropping systems with a rotation cycle of 20 years or less. Assigning the share of total LUC emissions for each year in the LUC assessment period is determined using a linear amortization method (see above).

The 20-year default LUC assessment period for LUC emissions accounting is derived from the default period used by the IPCC for carbon stocks on land to reach equilibrium after conversion.[11] Additionally, although LUC emissions are generally released to the atmosphere quickly following conversion, a land use conversion can enable continuous agricultural production for many years following the conversion event. Therefore, allocating all emissions from a LUC event in the year it occurs, and zero emissions to activities in subsequent years, would be inappropriate from both a physical and accounting perspective.

For land-based products with a cultivation cycle or rotation period of more than 20 years, the number of years in that cycle or period is used as the LUC assessment period instead of the 20-year default (also set prior to and inclusive of the inventory reporting year). For example, an oil palm plantation with a 25-year cultivation cycle seeking to report its LUC emissions in 2025 would need to evaluate whether any LUC occurred on land in the scope 1 spatial boundary during the period 2001–2025.

Table 7.4 Determining the LUC assessment period based on crop cycle or rotation periods

Product cultivation cycle or rotation period	LUC assessment period	Example
≤ 20 years	20 years (default requirement)	A company purchases soybeans in 2025 (i.e., the inventory reporting year). Because soy is an annual crop, the company uses the default assessment period of 20 years prior to and inclusive of the reporting year (i.e., 2006–2025).
> 20 years	Equal to the rotation period or harvest cycle	A company purchases palm oil in 2025 (i.e., the inventory reporting year). The average lifespan of a commercial oil palm plantation is 25 years.[12] The company sets an assessment period of 25 years prior to and inclusive of the reporting year (i.e., 2001–2025).

Table 7.4 describes how to define the LUC assessment period. For a visual depiction of how to set the assessment period and apply linear amortization, see Figure 7.3 and Table 7.11. In this example, a company estimating a dLUC emission factor for Brazilian soy sourced from an LMU in the year 2025 would evaluate LUC emissions that occurred on that LMU for the years from 2006 to 2025. For the year 2010, they would determine the total LUC emissions that occurred on the LMU in 2010 and apply the linear amortization factor of 2.25 percent (since 2010 is year 16 in the LUC assessment period; see Table 7.11). They would apply a similar calculation for every other year in the assessment period, sum the resulting amortized LUC emissions, then divide those LUC emissions by the total soy production on the LMU in 2025 to determine the LMU-level dLUC soy emission factor for 2025.

Linear amortization

LUC emissions are released to the atmosphere relatively quickly following a conversion event, but a LUC typically enables continuous agricultural production (or related land uses) thereafter. Therefore, LUC emissions are not exclusively assigned to corporate activities that occurred on that land in the same year the LUC occurred (and zero responsibility for LUC emissions assigned to activities that occur on that land in the subsequent year and thereafter). Instead, using a amortization approach, responsibility for LUC emissions is assigned across activities occurring on that land following the LUC conversion event over the remainder of a LUC assessment period. From the reporting company's perspective, the LUC assessment period is retrospective relative to the reporting year: if LUC occurred in any year within the LUC assessment period, the reporting company is responsible for a portion of the total LUC emissions (i.e., even if the reporting company did not own or control or source from the relevant land in the year when the LUC occurred).

The required amortization method for LUC emissions accounting in this *Standard* is linear amortization (see Requirement 10). Conceptually, this approach attributes greater responsibility to company activities (in the reporting year) for LUC emissions that occurred more recently in the LUC assessment period. Less responsibility is attributed for LUC emissions that occurred further back (i.e., more historically) in the LUC assessment period. Using linear amortization, responsibility for land use change emissions decreases annually (by 0.5 percent) in a linear fashion (beginning at 9.75 percent) across the LUC assessment period, so that the total is 100 percent over 20 years (see Figure 7.3). Responsibility for a portion of total LUC emissions is assigned using a linear amortization factor (see Table 7.11), so that, altogether, 100 percent of the total emissions are assigned.

Linear amortization is designed to apply to land-based products harvested over an annual production cycle so that each year in the LUC assessment period is allocated a share of total LUC emissions. For land-based products that are produced over a harvest cycle or rotation period greater than one year, companies must ensure that LUC emissions from all years of the harvest cycle or rotation period within the LUC assessment period are allocated to that product. For example, consider a company that clears a natural forest and plants the converted LMU as a short-rotation forest plantation in 2011, which is then harvested at the end of a 15-year rotation period (i.e., 2025). Linear amortization assigns the LUC emissions from the initial conversion event to each year between planting and harvest (i.e., each year between 2011 and 2025 is assigned a portion of the total LUC emissions due to the subcategory land use change). Since wood is only harvested at the end of the rotation period, the company must ensure that the LUC emissions that would otherwise be allocated to each year in the LUC assessment period (i.e., each year from initial conversion to a plantation to the year of harvest) are allocated to the harvested wood using linear amortization (i.e., the harvested wood is allocated the sum of the LUC emissions allocated to each year from 2011 to 2025), as opposed to only assigning LUC emissions to the final year in the rotation (i.e., the harvested wood only accounts for LUC emissions allocated to 2025). If LUC emissions for each year the product is being grown are not attributed to the final plantation harvest, then total LUC emissions due to the initial land conversion will not be fully accounted for.

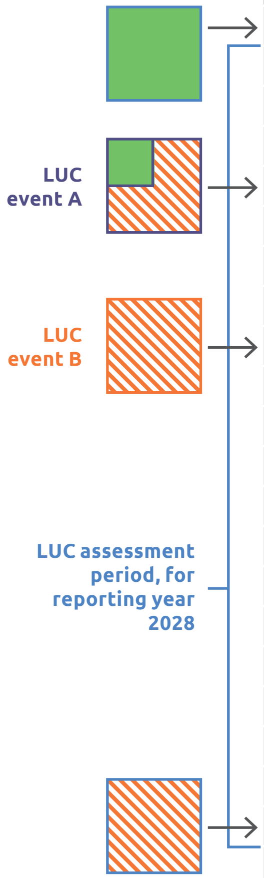
Note that because the LUC assessment period is 20 years or more, LUC emissions may persist in the corporate inventory even as LUC event(s) recede into the past. For example, if a company ends deforestation in its supply chain in 2030, some level of LUC emissions would persist in the inventory until reporting year 2050 (i.e., across the duration of the 20-year LUC assessment period). Companies should not switch their sourcing to avoid legacy LUC emissions. For further calculation guidance on linear amortization, see Step 3 in Section 7.5.3.1 below.

Table 7.5 Practical implications of linear amortization

Implication	Explanation
Linear amortization puts more emphasis on the impacts of recent land conversion in a company's operations or supply chain	Pathways to stabilize the climate at 1.5 degrees of warming require halting, and then reversing, global net LUC emissions by or around 2030.[a] Linear amortization weights the impacts of recent land use decisions more heavily, providing a stronger incentive for companies to halt land conversion and prevent new land conversion in their operations and supply chains.
Companies should consider implications for short-term targets, commitments, and certifications	Given the implication above, halting land conversion and preventing new land conversion are therefore accounted as a greater benefit. This can be important for planning, particularly against short-term targets, and for companies working with deforestation-free certifications, commitments, or policies. For more guidance on the links between certification and corporate GHG accounting, see Section 7.4.8.
Linear amortization provides better insights for sourcing decisions in countries or areas with very recent or ongoing deforestation	Linear amortization weighs relatively recent deforestation more heavily than equal amortization. Using equal amortization, very recent LUC impacts would be "diluted" if averaged equally over 20 years.
Linear amortization avoids abrupt cut-offs when accounting and reporting LUC emissions	Linear amortization addresses the shortcomings of the equal amortization method by avoiding the effects of an abrupt "cut off" at the end of the LUC assessment period.

Note: a. IPCC 2023.

Figure 7.3 Applying linear amortization to calculate LUC emissions



Reporting year	Total LUC emissions ($t\ CO_2e$)	Linear amortization factor, LUC event A	Linear amortization factor, LUC event B	Total, amortized LUC emissions in reporting year ($t\ CO_2e$)
2008				
2009				
2010				
2011				
2012	**3750**	9.75%		**366**
2013		9.25%		**347**
2014		8.75%		**328**
2015		8.25%		**309**
2016	**1250**	7.75%	9.75%	**413**
2017		7.25%	9.25%	**388**
2018		6.75%	8.75%	**363**
2019		6.25%	8.25%	**338**
2020		5.75%	7.75%	**313**
2021		5.25%	7.25%	**288**
2022		4.75%	6.75%	**263**
2023		4.25%	6.25%	**238**
2024		3.75%	5.75%	**213**
2025		3.25%	5.25%	**188**
2026		2.75%	4.75%	**163**
2027		2.25%	4.25%	**138**
2028		1.75%	3.75%	**113**
2029		1.25%	3.25%	**88**
2030		0.75%	2.75%	**63**
2031		0.25%	2.25%	**38**
2032			1.75%	**22**
2033			1.25%	**16**
2034			0.75%	**9**
2035			0.25%	**3**
Total	***5000***	***100%***	***100%***	***5000***

2012: (**3750** tCO_2e * **0.0975**) = 366 tCO_2e

2016: (**3750** tCO_2e * **0.0775**) + (**1250** tCO_2e * **0.0975**) = 413 tCO_2e

2028: (**3750** tCO_2e * **0.0175**) + (**1250** tCO_2e * **0.0375**) = 113 tCO_2e

2033: (**1250** tCO_2e * **0.0125**) = 16 tCO_2e

Forest land   Agricultural land

Note: a. Figure shows a simplified example of calculating scope 1 LUC emissions using the LMU-level dLUC calculation approach.

Equal Amortization

Equal amortization is an alternative amortization method to assign responsibility for LUC emissions that occurred in the LUC assessment period. Equal amortization assigns an equal share of LUC emissions to each year in the LUC assessment period following the conversion event across the remainder of the LUC assessment period. Conceptually, equal amortization assigns responsibility to LUC emissions equally to each year in the LUC assessment period, regardless of how recently the conversion event occurred (i.e., one year ago or 20 years ago).

Linear, not equal, amortization is the required amortization method for LUC emissions accounting in this *Standard*. Equal amortization is the recommended alternative amortization method in “Scenario B” when applying a jurisdictional dLUC calculation approach (see Table 7.1 in the *Standard*) and only two years of land use/land cover data are available (e.g., LUC maps are only available every 10 years). In this specific situation, the reporting company has access to only two years of complete land use/land cover maps for the jurisdiction (e.g., country) or sourcing region of origin in the LUC assessment period.

This particular data limitation may prevent the company from complete and accurate accounting for annual LUC emissions using the linear amortization method. If the company only has, e.g., a land use/land cover map for the first and last year in the LUC assessment period, it cannot be determined whether the interim land use conversion (i.e., revealed by comparing the change between these two “snapshots” in time) occurred relatively early on (more historically) or late (closer to the present) in the LUC assessment period. Technically, the conversion occurring between the two “snapshots” could have all occurred in year 19 of the assessment period or all in year two, and the resulting emissions would be weighted very differently if applying linear amortization. To balance potentially significant over- or underestimation of responsibility for the interim LUC emissions in this particular case, equal amortization provides a conservative “median” estimate and is the recommended approach. In the specific case described in “Scenario B,” a company must disclose and justify why an equal amortization method was used.

7.4.6 Allocation of LUC emissions across products

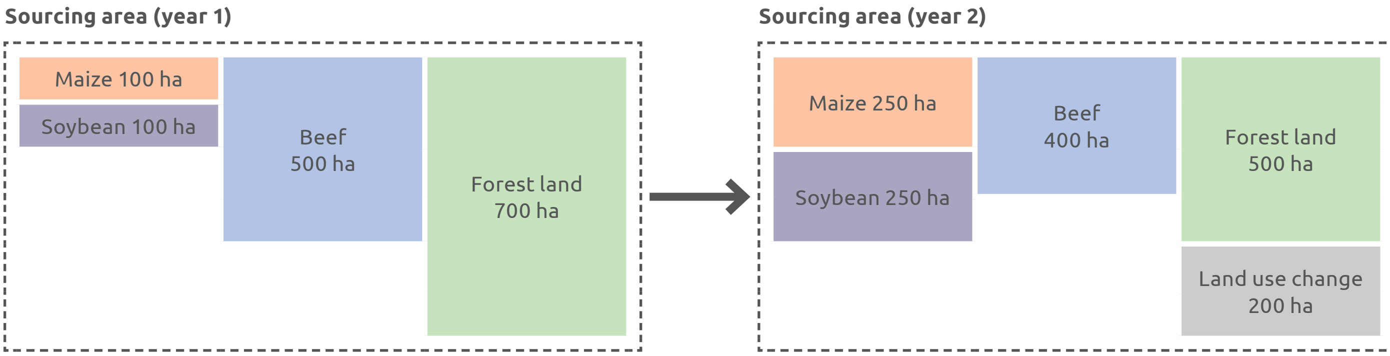
The sLUC calculation approach is used to account for scope 3 LUC emissions when the reporting company has traceability only to a jurisdiction or sourcing region of origin. The sLUC calculation approach attributes responsibility for LUC emissions in a jurisdiction or sourcing region to products sourced from that scope 3 spatial boundary using statistical data (i.e., crop production statistics) as a proxy. There are two sLUC allocation methods: the product expansion allocation method and the shared responsibility allocation method (Table 7.6). These methods allocate LUC emissions according to the relative expansion or relative total area of productive land in a sourcing area, respectively, in a given year in the LUC assessment period (Figure 7.4).

As set forth in this *Standard*, the product expansion allocation method is required. Using the product expansion allocation method, only products whose land area has expanded in a given year in the sourcing area are allocated a share of sLUC emissions that occurred in that year in the sourcing area. For the shared responsibility allocation method, all products produced in the sourcing area are included in the analysis and allocated a share of sLUC emissions.

Table 7.6 sLUC allocation methods

sLUC allocation method	Description
Product expansion allocation method (***see Equation 7.3 in Section 7.5***)	**Required sLUC allocation method** Used to allocate (i.e., assign responsibility) sLUC emissions to land-based products produced in a given sourcing area based on the relative expansion of lands used to produce land-based products in that given area. *Note:* This approach is referred to as the "crop-specific approach" in other methodologies.
Shared responsibility allocation method (***see Equation 7.4 in Section 7.5***)	Used to allocate (i.e., assign responsibility) sLUC emissions to land-based products produced in a given area based on the relative total area of attributable productive land used to produce a specific land-based product compared to other products in a given sourcing area. As set forth in Requirement 10, the shared responsibility allocation method may be used in the limited exceptional case identified in Section 7.3 in the *Standard* (see "sLUC allocation method exception"). Companies must justify why the use of the shared responsibility allocation method applies to this specific case.

Figure 7.4 **Allocating sLUC emissions using the product expansion allocation and shared responsibility allocation methods**



Product expansion allocation method (required)				Shared responsibility allocation method (allowed where data is limited)[b]			
Product	**Plain language description**	**Mathematical description**	**Product allocation factor (PAF), year 2**	**Product**	**Plain language description**	**Mathematical description**	**Product allocation factor (PAF), year 2**
Maize	Expansion of maize divided by the total expansion of agricultural land in the sourcing area	(250 - 100)/[(250 - 100) + (250 - 100)] = 150 / 300 = 0.5	50%	**Maize**	Total area of maize divided by the total area of all agricultural land in the sourcing	(250 / [(250 + 250 + 400)] = 250 / 900 = 0.28	28%
Soybean	Expansion of soy divided by the total expansion of agricultural land in the sourcing area	(250 - 100) / [(250 - 100) + (250 - 100)] = 150 / 300 = 0.5	50%	**Soybean**	Total area of soy divided by the total area of all agricultural land in the sourcing	(250 / [(250 + 250 + 400)] = 250 / 900 = 0.28	28%
Beef[a]	Expansion of beef divided by the total expansion of agricultural land in the sourcing area	(400 - 500) = <0 (i.e., no expansion)	0%	**Beef**	Total area of beef divided by the total area of all agricultural land in the sourcing	400 / [(250 + 250 + 400)] = 250 / 900 = 0.44	44%

Notes: a. When applying the product expansion allocation method, products whose area has not expanded in assessment area between year *yLUC+1* and year *yLUC* are not allocated a portion of LUC emissions that occurred in the assessment area. (i.e., *PAF_PE* = 0 for products *k* where $A_{a,k,yLUC} - A_{a,k,yLUC+1} < 0$). In the example shown above, beef pastureland does not expand from year 1 to year 2 and is assigned a PAF of zero for year 2 using the product expansion allocation method; b. The shared responsibility allocation method is allowed only where data is limited; see "Recommendations for transitioning from sLUC to dLUC calculation approaches" in Section 7.3 for details.

When a company can establish traceability to an LMU or set of LMUs producing a single agricultural product, allocation of LUC emissions via proxy is not necessary, as LUC emissions can instead be allocated directly. When a company can establish traceability to an LMU or set of LMUs that have multiple outputs, the allocation recommendations and guidance provided in Section 6.4.5 apply to dLUC emissions from that LMU or set of LMUs.

Note that allocation is often needed at other stages in the value chain (e.g., to allocate emissions and other metrics to co-products produced at a processing facility), where the general allocation recommendations and guidance in Section 6.4.5 also apply to LUC emissions, regardless of whether dLUC or sLUC calculation approaches are applied.

7.4.7 Water reservoir land use change emissions

The creation of a water reservoir represents a LUC, and the emissions released from a water reservoir are accounted for as LUC emissions. Following impoundment, water reservoirs create anaerobic conditions that stimulate CO_2 and CH_4 emissions from the decomposition of organic matter from land-based carbon pools within the previous land use. This section provides guidance on how to account for CH_4 and CO_2 emissions from water reservoirs in a company's operations or value chain.

Companies that own or control water reservoirs account for GHG emissions following the establishment of a water reservoir as scope 1 LUC emissions. Companies that purchase or acquire electricity generated from hydropower or other services associated with the water reservoir (e.g., source agricultural products irrigated with water stored within the reservoir) account for emissions from the water reservoir as LUC emissions in scope 3, category 3 for purchased electricity from hydropower[13] or scope 3, category 1 for other purchased goods or services. Note that emissions due to the construction, operation, and maintenance of a water reservoir (e.g., GHG emissions from fuel use within operations at the facility) are not included in LUC emissions. Additional guidance on accounting for such emissions can be found in sector-specific guidance, such as the Hydropower Sustainability Standard.[14]

As set forth in Requirement 10.2, companies accounting for water reservoir LUC emissions are recommended to follow the stated hierarchy of methods and prioritize higher-tier approaches when the relevant data is available. When applying a higher-tier approach, it is recommended to use a 5–10 year average for temporal representativeness that addresses seasonality and annual changes. Annual data can be used if available and if considered to be the most accurate data, particularly when using on-site measurements.

Carbon dioxide (CO_2) emissions due to water reservoir land use change

According to the IPCC's *2019 Refinement*, statistical analyses on reservoirs indicate that there is a rapid surge of emissions immediately following flooding, after which emissions return to a relatively stable level. The conversion of land to a water reservoir affects all land-based carbon pools, and evidence suggests that elevated CO_2 emitted during the first two decades after flooding results from the decay of some of the organic matter on the land prior to flooding. After this initial phase, the CO_2 emitted from water reservoirs is largely derived from carbon input from the catchment, which is estimated as emissions in other land emission accounting categories.

As set forth in Requirement 10.2, CO_2 emissions from land converted to a water reservoir should be accounted for as LUC emissions during the first 20 years after the land use change (i.e., the creation of the water reservoir). To estimate CO_2 emissions from water reservoirs and other flooded lands, companies can apply IPCC Tier 1 emission factors[15] and associated activity data using Equation 7.13 in Section 7.5.3.4, or use higher-tier approaches. Note that (unlike the general accounting approach for LUC emissions outlined in Section 7.4.5) CO_2 emissions from water reservoirs are not time-amortized across the assessment period for water reservoirs.

Methane (CH_4) emissions due to water reservoir land use change

The rate of methane production from water reservoirs and other flooded lands varies based on the water temperature, the type and quantity of organic inputs (e.g., submerged vegetation), the type of flooded soils present, the sedimentation rate, and the water body size, depth, orientation, and age. The age of a water reservoir is a significant variable due to the higher rate of organic matter decomposition, and thus methane emissions, when land is first flooded. Following the creation of a water reservoir, elevated CH_4 emissions can occur in the first 20 years and then generally return to a stable level.

As set forth in Requirement 10.2, CH_4 emissions from land converted to a water reservoir should be accounted for during the first 100 years after the LUC (i.e., the creation of the water reservoir). To estimate methane emissions from water reservoirs and other flooded lands, companies can apply Equation 7.14 in Section 7.5.3.4 using IPCC Tier 1 emission factors[16] and associated activity data, or a higher-tier approach. When estimating methane emissions from water reservoirs, companies should use emission factors that are specific to the water reservoir's age and climate (see Section 7.5.3.4 for calculation guidance). All CH_4 emissions during the 100-year assessment period are accounted for as LUC emissions. Note that (unlike the general accounting approach for LUC emissions outlined in 7.4.5) CH_4 emissions from water reservoirs are not time-amortized across the assessment period for water reservoirs.

When estimating methane emissions from other constructed water bodies, companies should use emission factors specific to freshwater ponds, saline ponds, canals, or ditches, and do not need to estimate downstream methane emissions. For accounting and calculation guidance for other such constructed water bodies, see Section 7.5.3.4 and Chapter 7 in Volume 4 of the IPCC's *2019 Refinement*.[17]

7.4.8 Integrating certification into LUC emissions accounting

Third-party certification programs aim to improve environmental and social outcomes in supply chains. Some certification programs aim to eliminate gross LUC in the supply chains of certain products (e.g., "deforestation-free" and "conversion-free" certification programs). In order to integrate certification into LUC accounting that satisfies the requirements in this *Standard*, companies need information about the objective of the certification scheme, the level of traceability established by the certification scheme, the time and spatial boundaries in the certification scheme, and the assurance and verification process of the certification scheme.

Companies may use no-deforestation/no-conversion certification to demonstrate traceability or evaluate when LUC occurred within relevant LMUs. Companies should use certification that demonstrates they have physical traceability to relevant LMUs, but may demonstrate they have traceability of impact subject to the interim traceability requirement (see Requirement 8 and Section 5.4.1 in the *Guidance*). Companies that use certification to support LUC emissions accounting should consider the following:

- **Cut-off date**: The cut-off date is the date after which deforestation or conversion renders a given area or production unit non-compliant with commitments (e.g., deforestation-free or conversion-free).[18] Only certification programs that apply a cut-off date that is at least 20 years prior to the reporting year (or longer, depending on the relevant LUC assessment period) can be used to demonstrate that zero LUC emissions are attributed to the certified volumes. Certification programs with a cut-off date less than 20 years prior to the reporting year cannot be used to justify zero LUC emissions, as deforestation or conversion may have occurred in years prior to the cut-off date, but still within the LUC assessment period. In these cases, the certification may still provide relevant information to support dLUC emission calculations (e.g., information on LMU boundaries or polygons where certified volumes were produced can be integrated in an analysis of dLUC emissions on those respective LMUs).
- **Chain of custody model**: A chain of custody model is an approach taken to control inputs and outputs and transfer specified characteristics (e.g., "deforestation-free") as the ownership of the material or product transfers from one entity to another in a value chain, from the LMU(s) where the raw material was produced to the product's end use. If companies seek to demonstrate physical traceability of the products a company purchases or sells to a sourcing region (or specific LMU or set of LMUs, or specific harvested area or set of harvested areas), companies must implement traceability systems that apply identity preserved, segregation, controlled blending, and mass balance chain of custody models, as specified in Requirement 8. These chain of custody models provide the highest integrity methods for traceability to suppliers by either physically separating materials or tracking the mixing process to ensure a known quantity of purchased materials can be directly related to specific sources.

Only certification schemes using chain of custody models that ensure physical traceability to specific lands where the materials were produced can be used to support land use change emissions accounting in the physical GHG inventory using the dLUC calculation approach. For example, companies purchasing deforestation-free certified palm oil that use identity-preserved or segregation chain of custody models that establish traceability back to the relevant oil palm plantations or smallholder producers may use information from the certification program to justify the scope 3 spatial boundaries associated with the certified oil palm purchased by the company, which the company can then use to quantify LUC emissions occurring during the LUC assessment period using the dLUC calculation approach.

As set forth in the reporting requirements in Section 6.2.2, companies that use certification or chain of custody programs are required to report the type of certification programs or chain-of-custody models used to demonstrate traceability.

7.5 Calculating land use change emissions

Section 7.5 provides calculation guidance to calculate land use change emissions, including guidance for how to choose data and methods, and the equations to complete the calculations. Figure 7.5 provides an overview of Section 7.5.

Figure 7.5 Overview of Section 7.5

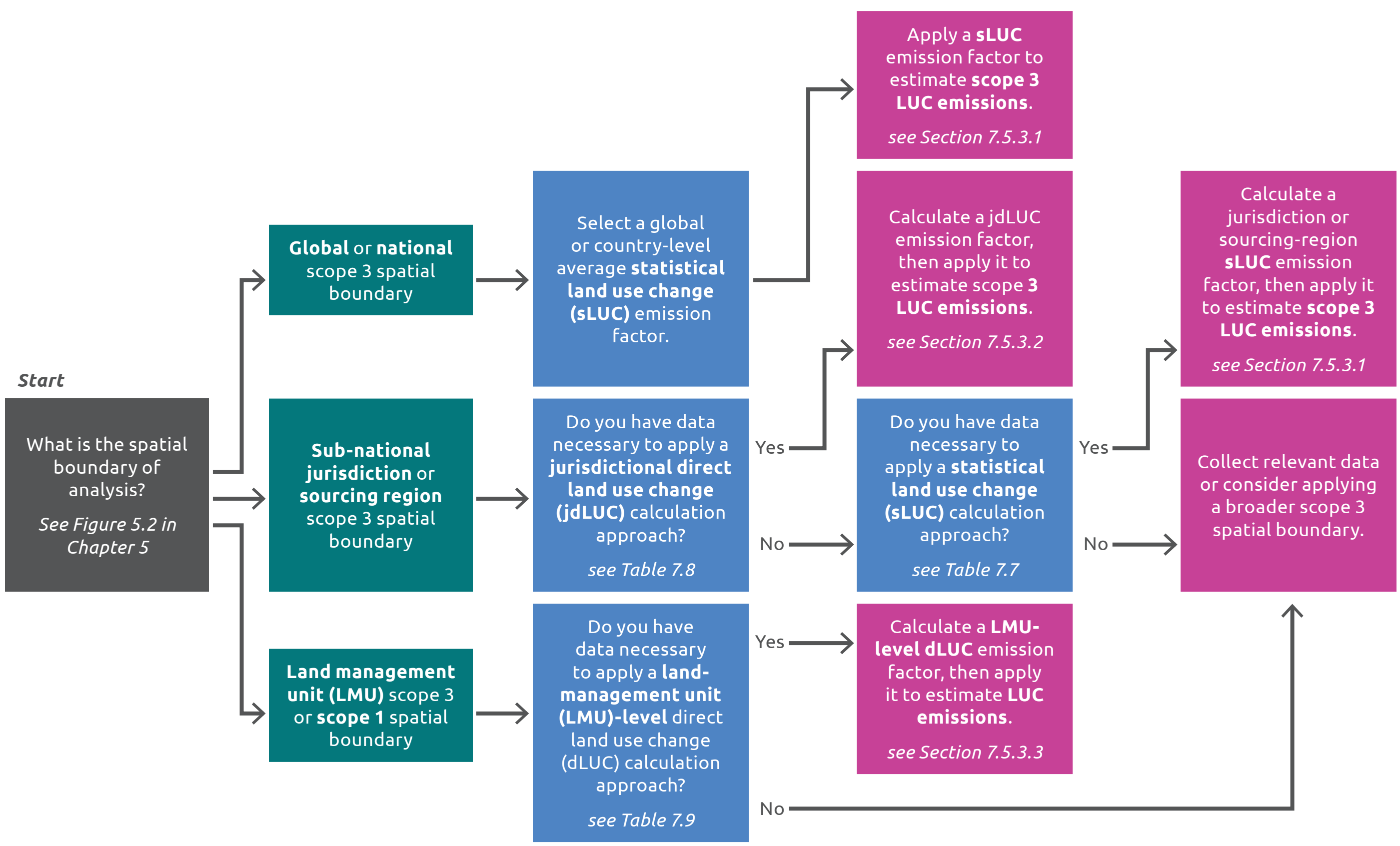
Section 7.5.1 Choosing a land use change (LUC) emission factor	→	Section 7.5.2 Data for LUC emissions calculation approaches	→	Section 7.5.3 Calculating LUC emissions
How does my company decide which calculation approach to use?		What data is needed to operationalize certain calculation approaches?		What equations are used to perform the relevant calculation?

7.5.1 Choosing a land use change emission factor

Figure 7.6 provides a high-level decision tree to help companies identify which emission factor calculation approach is appropriate in which context, and Section 7.5.2 discusses the data required to implement each calculation approach. Generally, LUC emissions can be estimated from literature-based LUC calculation tools, directly from field-based estimates, derived from satellite imagery, or using a combination of field data, imagery, and modeling. Companies may apply different LUC calculation approaches by product type and sourcing jurisdiction based on their level of traceability and prioritization of data collection. Companies are required to apply the same calculation approach for a given product by sourcing jurisdiction each year or re-baseline, following Requirements 10 and 28, respectively.

As shown in Figure 7.6, the first step to selecting or calculating a LUC emission factor is to determine the spatial boundary of analysis, which depends in turn on the level of traceability the reporting company can establish (see Table 5.1). The next steps to selecting or calculating a LUC emission factor depend on data availability. When establishing traceability and setting the scope 3 spatial boundary when accounting for LUC emissions, companies should also follow the recommendations in Section 5.3.

Figure 7.6 Decision tree for calculating land use change emissions



7.5.2 Data for land use change emissions calculation approaches

Sections 7.5.2.1–7.5.2.3 describe the types of data needed to implement different LUC emissions calculation approaches.

7.5.2.1 Data for a global or country-level sLUC emission factor

Table 7.7 Data needed for a global or country-level sLUC emission factor

Data	Description
Global or country-level agricultural production statistics	Production statistics (e.g., annual production, yields) for all agricultural goods produced in the global or country-level scope 3 spatial boundary in most years (but ideally each year) of the LUC assessment period. Production statistics are needed to allocate LUC emissions that occurred in each year of the LUC assessment period to crops produced in that year using the product expansion allocation method. Spatialized, statistical crop production data can be used in a "spatial" sLUC calculation approach. Some models provide gridded maps of global, predicted crop distribution, based on, e.g., agronomic, economic, and biophysical constraints.
Global or country-level land cover/ land use data	Land use/land cover data for all productive agricultural land in the global or country-level scope 3 spatial boundary in most years, but ideally each year, of the LUC assessment period. Land cover/land use data (e.g., land use/land cover statistics or remote sensing data) for the sourcing area are needed to estimate annual LUC emissions that occurred in each year of the LUC assessment period.
Carbon stock data	Carbon stock data (i.e., pre-conversion carbon stock data) for all lands in the scope 3 spatial boundary in each year of the LUC assessment period. Carbon stock data for the sourcing area are needed to estimate annual LUC emissions that occurred in each year of the LUC assessment period. This data may represent average carbon stock factors (e.g., from IPCC reports or national inventories) or data based on remote sensing imagery or other models.

7.5.2.2 Data for a subnational jurisdiction or sourcing region jdLUC emission factor

Table 7.8 Data for a subnational jurisdiction or sourcing region jdLUC emission factor

Data	Description
Jurisdiction- or sourcing region-level crop map	A complete, temporally consistent crop map (i.e., annual, crop-specific land use layer) for all attributable productive lands in the scope 3 spatial boundary in the reporting year. "Complete" means that the mask is spatially complete (i.e., includes all attributable productive lands in the scope 3 boundary), but does not mean that all land uses must be represented (e.g., forests, wetlands, etc.). For example, if the reporting company sources cocoa from a subnational jurisdiction, a complete crop map for all lands that produced cocoa in that jurisdiction in most years of the LUC assessment period is needed. Superimposing this crop map with land cover/land use data spatially locates LUC that occurred in the LUC assessment period on all attributable productive lands in the scope 3 spatial boundary.
Jurisdiction- or sourcing region-level land cover/ land use data	Land use/land cover data in most years (should include the first and last year) but ideally each year of the LUC assessment period (see also Table 7.1), for all attributable productive agricultural land in the jurisdiction or sourcing region scope 3 spatial boundary. Land cover/land use data for the sourcing area is needed to estimate annual LUC emissions that occurred in each year of the LUC assessment period.
Carbon stock data	Carbon stock data (i.e., pre-conversion carbon stock data) for all lands in the scope 3 spatial boundary in each year of the LUC assessment period. Carbon stock data for the sourcing area is needed to estimate annual LUC emissions that occurred in each year of the assessment period. This data may represent average carbon stock factors (e.g., from IPCC reports or national inventories) or data based on remote sensing imagery or other models.

7.5.2.3 Data for an LMU-level dLUC emission factor (scope 3) or scope 1 LMU-level dLUC calculations

Table 7.9 Data for an LMU-level dLUC emission factor (scope 3) or scope 1 LMU-level dLUC calculations

Data	Description
Land management unit (LMU) spatial data	LMU-level polygons (i.e., shapefiles) or GPS coordinates are needed to spatially geolocate sourcing LMUs. Superimposing LMU-level spatial data with land cover/land use data spatially locates LUC that occurred on the LMU in the LUC assessment period.
Land cover/land use data for the LMU area	Land use/land cover data for all land in the LMU scope 3 spatial boundary in most years (but ideally each year) of the LUC assessment period. Land cover/land use data for the LMU is needed to estimate annual LUC emissions that occurred in each year of the LUC assessment period.
Carbon stock data	Carbon stock data for all lands in the LMU in each year of the LUC assessment period. Carbon stock data for the LMU is needed to estimate annual LUC emissions that occurred in each year of the LUC assessment period. This data may represent average carbon stock factors (e.g., from IPCC reports or national inventories) or data based on remote sensing imagery or other models.

7.5.3 Calculating land use change emissions

This section provides calculation guidance to calculate scope 1 and/or scope 3 LUC emissions using the:

- **Statistical land use change (sLUC)** calculation approach (Section 7.5.3.1)
- **Jurisdictional direct land use change (jdLUC)** calculation approach (Section 7.5.3.2)
- **Land management unit (LMU)-level dLUC** calculation approach (Section 7.5.3.3)

Specific calculation guidance for water reservoir LUC emissions is provided in Section 7.5.3.4.

7.5.3.1 Calculating LUC emissions using the sLUC calculation approach

When companies have traceability only to a jurisdiction or sourcing region level (or have no traceability) in their value chain, and additional data needed to implement a “jurisdictional” dLUC calculation approach are not available (Table 7.8), companies should apply the sLUC calculation approach. Most companies applying an sLUC calculation approach at a jurisdictional level can select a relevant sLUC emission factor from an LCA database or other tool that follows the sLUC calculation approach described below. Such companies can skip ahead to step 5 to apply that sLUC emission factor to estimate their scope 3 LUC emissions.

Companies estimating sLUC emissions at a sourcing region level, database providers developing sLUC emission factors, or other third-party service providers generating sLUC emission factors can apply the sLUC calculation approach described below. An overview of the steps for calculating scope 3 sLUC emissions using the sLUC calculation approach is shown in Table 7.10.

Table 7.10 Overview of steps of the sLUC calculation approach

Step	Reference
Step 1: Calculate total LUC emissions that occurred in the sourcing area in each year of the LUC assessment period	**Equation 7.1, Equation 7.2**
Step 2: Allocate LUC emissions occurring in each year of the LUC assessment period to products produced in the sourcing area, using the product expansion allocation method	**Equation 7.3, Figure 7.4**
Step 3: Using linear amortization, amortize sLUC emissions across the LUC assessment period	**Table 7.11, Equation 7.5**
Step 4: Calculate the sLUC emission factor	**Equation 7.6**
Step 5: Calculate total product sLUC emissions	**Equation 7.7**

STEP 1: CALCULATE TOTAL LUC EMISSIONS IN THE SOURCING AREA IN EACH YEAR OF THE LUC ASSESSMENT PERIOD

GHG emissions from LUC are primarily due to CO_2 emissions from land carbon stock changes in biomass, dead organic matter, and soil carbon that occur upon conversion. LUC GHG emissions also include CH_4 and N_2O emissions from biomass burning, and N_2O emissions associated with nitrogen mineralization of soil organic matter in mineral soils and drained peatlands, as shown in Equation 7.1. Equations to estimate other non-CO_2 GHG emissions from LUC can be found in Chapter 10 (see Equations 10.11, 10.14, and 10.17).

The total carbon stock loss due to LUC is estimated based on the difference between the carbon stock of the previous land use and the carbon stocks of the land use post-conversion, as illustrated in Equation 7.2. Data on the land area that experienced LUC should include all land areas within the relevant spatial boundary that experienced LUC during the assessment period. Note that when applying an sLUC approach, LUC emissions should be estimated across all productive agricultural lands within the jurisdictional or sourcing region scope 3 spatial boundary, not just on *attributable* productive lands in that scope 3 spatial boundary. Where companies have such spatial data to identify attributable productive lands, they can apply a jurisdictional dLUC approach (see Section 7.5.3.2 for details). Where available, annual gross LUC data with a resolution relevant to the spatial boundary should be used to determine the total area experiencing LUC each year, for all years included in the LUC assessment period. When estimating total carbon stock losses over a given stratum (i.e., stratum in the broader scope 1 or 3 spatial boundary; for description of strata, see Section 6.4.2.1) that has experienced LUC, carbon stock estimates may be stratified or categorized by climate, ecological zone, soil type, management practices, or other potential factors impacting carbon stocks within the given stratum.

Equation 7.1 GHG emissions due to land use change

$$GHG\_LUC_{a,yLUC} = CO2\_LUC_{a,yLUC} + N2O\_LUC_{a,yLUC} + CH4\_LUC_{a,yLUC}$$

$$CO2\_LUC_{a,yLUC} = \Delta C_{a,yLUC} \times \frac{44}{12}$$

$$CH4\_LUC_{a,yLUC} = CH4\_BB \times GWP\_CH4$$

$$N2O\_LUC_{a,yLUC} = \left(N2O\_BB + N2O\_OSdir + \left((F\_SOM \times EF_1) \times \frac{44}{28} \times 10^{-3}\right)\right) \times GWP\_N2O$$

Description		Unit	Source
$GHG\_LUC_{a,yLUC}$	Total GHG emissions due to LUC in assessment area a, in year yLUC of the LUC assessment period	tonnes CO_2e (year)$^{-1}$	Calculated
$CO2\_LUC_{a,yLUC}$	Total CO_2 emissions due to LUC in assessment area a, in year yLUC of the LUC assessment period	tonnes CO_2 (year)$^{-1}$	Calculated
$CH4\_LUC_{a,yLUC}$	Total CH_4 emissions due to LUC in assessment area a, in year yLUC of the LUC assessment period	tonnes CO_2e (year)$^{-1}$	Calculated
$N2O\_LUC_{a,yLUC}$	Total N_2O emissions due to LUC in assessment area a, in year yLUC of the LUC assessment period	tonnes CO_2e (year)$^{-1}$	Calculated
$\Delta C_{a,yLUC}$	Total gross carbon stock loss* due to LUC in assessment area a, in year yLUC of the LUC assessment period	tonnes C (year)$^{-1}$	Equation 7.2
$CH4\_BB$	CH_4 emissions from biomass burning during LUC	tonnes GHG (year)$^{-1}$	Equation 10.17
$N2O\_BB$	N_2O emissions from biomass burning during LUC	tonnes GHG (year)$^{-1}$	Equation 10.17
GWP_CH4	100-year CH_4 global warming potential	tonnes CO_2e (tonne GHG)$^{-1}$	Default value
GWP_N2O	100-year N_2O global warming potential	tonnes CO_2e (tonne GHG)$^{-1}$	Default value
$N2O\_OSdir$	Total direct N_2O emissions due to draining or other disturbance of organic soils (OS) due to LUC	tonnes N_2O (year)$^{-1}$	Equation 10.14
F_SOM	N mineralized in mineral soils as a result of soil organic matter loss due to LUC	kg N (year)$^{-1}$	Equation 10.11
EF_1	Emission factor for N_2O emissions from N inputs, from N mineralized as a result of soil organic matter losses	kg N_2O-N (kg N input)$^{-1}$	Default value
a	Assessment area (i.e., all lands in the sourcing region or jurisdiction for sLUC analysis; attributable productive lands in the sourcing region or jurisdiction for jdLUC; or all lands in the LMU for LMU-level dLUC)		User input
$yLUC$	Year in the LUC assessment period		Table 7.11
$44/12$	Conversion factor from C to CO_2		Constant
$44/28$	Conversion factor from N_2O-N to N_2O		Constant

Note: *For accounting guidance for net carbon stock gains following a land use change, see Section 7.4.1 and Requirement 10.

Equation 7.2 Carbon stock change due to land use change

$$\Delta C_{a,yLUC} = C\_post_{a,yLUC} - C\_pre_{a,yLUC}$$

Description		Unit	Source
$\Delta C_{a,yLUC}$	Total gross carbon stock loss* due to LUC in assessment area *a*, occurring in year *yLUC* of the LUC assessment period	tonnes C	Calculated
$C\_post_{a,yLUC}$	Total carbon stocks across all land-based carbon pools in the assessment area a post-conversion, in year *yLUC* of the LUC assessment period	tonnes C	Calculated
$C\_pre_{a,yLUC}$	Total carbon stocks across all land-based carbon pools in the assessment area a pre-land use change, in year *yLUC* of the LUC assessment period	tonnes C	User input
a	Assessment area (i.e., all lands in the sourcing region or jurisdiction for sLUC analysis; attributable productive lands in the sourcing region or jurisdiction for jdLUC; or all lands in the LMU for LMU-level dLUC)		User input
$yLUC$	Year in the LUC assessment period		Table 7.11

Note: *For accounting guidance for net carbon stock gains following a land use change, see Section 7.4.1 and Requirement 10.

STEP 2: ALLOCATE LUC EMISSIONS OCCURRING IN EACH YEAR OF THE LUC ASSESSMENT PERIOD TO PRODUCTS PRODUCED IN THE SOURCING AREA, USING THE PRODUCT EXPANSION ALLOCATION METHOD

As discussed in Section 7.4.6, the sLUC calculation approach attributes responsibility for LUC emissions in a jurisdiction or sourcing region to products sourced from that area using statistical data as a proxy. There are two sLUC allocation methods—the product expansion and shared responsibility allocation methods (Table 7.6)—which allocate LUC emissions according to the relative expansion or relative total area of productive land in a sourcing area, respectively, in a given year in the LUC assessment period. The product expansion allocation method is the required default allocation method (see the limited exception described in Requirement 10 and Section 7.3).

Equations 7.3 and 7.4 show how to calculate a product allocation factor (PAF) using the product expansion and shared responsibility allocation methods, respectively. Figure 7.4 provides a visual example of how the PAF is calculated using the product expansion allocation method. PAFs should be calculated for the product of interest for each year in the LUC assessment period.

Equation 7.3 Product expansion allocation method

$$PAF\_PE_{a,k,yLUC} = \frac{max(0,\ A_{a,k,yLUC} - A_{a,k,yLUC+1})}{\sum_{k}^{K_{a,yLUC}} max(0,\ A_{a,k,yLUC} - A_{a,k,yLUC+1})}$$

Description		Unit	Source
$PAF\_PE_{a,k,yLUC}$	Product allocation factor (PAF) calculated using the product expansion (PE) allocation method in assessment area *a*, for product *k**, in year *yLUC* of the LUC assessment period	dimensionless	Calculated
$A_{a,k,yLUC}$	Total productive land area in the assessment area *a*, that produced product *k*, in year *yLUC* of the LUC assessment period	ha	User input
$A_{a,k,yLUC}+1$	Total productive land area in the assessment area a, that produced product *k*, in the year *yLUC+1* of the LUC assessment period	ha	User input
a	Assessment area (i.e., all lands in the global, jurisdiction, or sourcing region scope 3 spatial boundary)		User input
k	Product produced in sourcing area *a*		User input
$K_{a,yLUC}$	Set of all products *k* produced in assessment area *a*, in year *yLUC* of the LUC assessment period		User input
$yLUC$	Year in the LUC assessment period		Table 7.11
$yLUC+1$	Year prior to year *yLUC* in the LUC assessment period		Table 7.11

Note: *Products *k* whose area has not expanded in assessment area a between year *yLUC+1* and year *yLUC* are not allocated a portion of LUC emissions that occurred in the assessment area (i.e., *PAF_PE* = 0 for products *k* where $A_{a,k,yLUC} - A_{a,k,yLUC+1} < 0$).

Equation 7.4 Shared responsibility allocation method

$$PAF\_SR_{a,k,yLUC} = \frac{A_{a,k,yLUC}}{\sum_{k}^{K_{a,yLUC}} (A_{a,k,yLUC})}$$

Description		Unit	Source
$PAF\_SR_{a,k,yLUC}$	Product allocation factor (PAF) calculated using the shared responsibility method in assessment area *a*, for product *k*, in year *yLUC* of the LUC assessment period	dimensionless	Calculated
$A_{a,k,yLUC}$	Total productive land area in the assessment area *a*, that produced product *k*, in year *yLUC* of the LUC assessment period	ha	User input
a	Assessment area (i.e., all lands in the global, jurisdiction, or sourcing region scope 3 spatial boundary)		User input
k	Product produced in assessment area *a*		User input
$K_{a,yLUC}$	Set of all products *k** produced in assessment area *a*, in year *yLUC* of the LUC assessment period		User input
$yLUC$	Year in the LUC assessment period		Table 7.11

Note: *All products *k* that were produced in assessment area a in the year *yLUC* in the assessment period are included in the analysis.

STEP 3: USING LINEAR AMORTIZATION, AMORTIZE SLUC EMISSIONS ACROSS THE LUC ASSESSMENT PERIOD

LUC emissions are released to the atmosphere relatively quickly following a conversion event, but LUC typically enables continuous agricultural production or related land uses thereafter. Therefore, LUC emissions are not exclusively assigned to corporate activities that occurred on that land during the same year the LUC conversion occurred (and zero emissions responsibility to activities that occur in the subsequent year and thereafter).

Using a amortization approach, responsibility for LUC emissions that have occurred on the land in a retrospective LUC assessment period is assigned across activities occurring on that land following the LUC conversion event across the remainder of an assessment period.

The required amortization method for LUC emissions accounting in this *Standard* is linear amortization. When using linear amortization to distribute LUC emissions across year in the LUC assessment period, companies need to first identify the year in which a LUC event occurred in relation to the reporting year. Table 7.11 defines the linear amortization factor (LAF) that is applied to amortize LUC emissions occurring in each year of the LUC assessment period for a 20-year LUC assessment period, as applied in Equation 7.6.

Table 7.11 Linear amortization factor (LAF) to amortize LUC emissions, by year in LUC assessment period

Year (*yLUC*) in LUC assessment period (*AP*)[a]	Number of years between *yLUC* and the reporting year (Y_p)	Linear amortization factor (LAF) (%; total = 100%)	Equal amortization factor (EAF) (%; total = 100%)
1	Inventory reporting year	9.75%	5%
2	1 year before reporting year	9.25%	5%
3	2 years before reporting year	8.75%	5%
4	...	8.25%	5%
5		7.75%	5%
6		7.25%	5%
7		6.75%	5%
8		6.25%	5%
9		5.75%	5%
10		5.25%	5%
11		4.75%	5%
12		4.25%	5%
13		3.75%	5%
14		3.25%	5%
15		2.75%	5%
16		2.25%	5%
17		1.75%	5%
18		1.25%	5%
19	18 years before reporting year	0.75%	5%
20	19 years before reporting year	0.25%	5%
20+	20 or more years before reporting year	0.00%	0%

Note: a. 20-year default LUC assessment period shown for demonstration purposes.

For products with a cultivation cycle or rotation period of more than 20 years, companies should apply equation 7.5 to determine an LAF for each year in the LUC assessment period. The year in the LUC assessment period (*yLUC*) is indexed numerically starting at 1 (i.e., the reporting year) up to the total number of years in the cultivation cycle or rotation period (i.e., the number of years in the LUC assessment period, *AP*). Table 7.11 shows how this indexing convention applies to the default 20-year LUC assessment period. Note that the index for *yLUC* increases as years move back in time retrospectively through the LUC assessment period. The years prior (y_p) is the number of years between year *yLUC* of the LUC assessment period and the reporting year. For example, a company seeks to determine the correct LAFs to apply when accounting for LUC emissions attributable to oil palm characterized by a 25-year rotation period (i.e., corresponding to a 25-year retrospective LUC assessment period). If the company is reporting in the year 2025, year 1 of the LUC assessment period (*yLUC* = 1) would be 2025 and have a y_p of 0; year 2 (*yLUC* = 2) would be 2024 with a y_p of 1; year 3 (*yLUC* = 3) would be 2023 with a y_p of 2; and continuing all the way back to year 25 (*yLUC* =25) of the LUC assessment period in 2001, with a y_p of 24.

Equation 7.5 Linear amortization factor equation

$$LAF_{yLUC} = \frac{2\left(AP - y_p - \frac{1}{2}\right)}{AP^2}$$

Description		Unit	Source
LAF_{yLUC}	Linear amortization factor (LAF) for year *yLUC* of the LUC assessment period	dimensionless	Calculated
AP	Number of years in the LUC assessment period	years	User input (Requirement 10)
Y_p	Years prior, i.e., the number of years between year *yLUC* of the LUC assessment period and the reporting year	years	User input
$yLUC$	Year in the LUC assessment period		Table 7.11

Linear amortization should be applied annually, but when annual land use/land cover data is not available in each year of the LUC assessment period (e.g., land use/land cover maps are only available every five years), linear amortization may be applied to those years in which data is available in the LUC assessment period to complete the accounting for LUC emissions. For example, if maps are only available in year 5 and year 10 of the LUC assessment period, any land use conversion that has occurred in the interim five-year period between year 10 and year 5 in the assessment period should conservatively be accounted for as occurring in year 5 of the assessment period, and the corresponding LAF for year 5 is used. Applying linear amortization to annual input data instead of, for example, five-year data, allows a more detailed overview as to why and where LUC occurs across time, including information on drivers and causes, and insights on how to address them.

STEP 4: CALCULATE THE SLUC EMISSION FACTOR

Equation 7.6 is used to calculate the sLUC emission factor. The sLUC emission factor is estimated by summing annual, amortized LUC emissions in the assessment area, allocated to a given product, for each year in the LUC assessment period. These summed emissions are divided by the total production of product (*k)* in the assessment area (*a*). For example, a company estimating an sLUC emission factor for Brazilian soy in the year 2025 would evaluate LUC emissions in Brazil for years from 2006 to 2025. For 2006 they would determine the total LUC emissions that occurred in Brazil in 2006, the product allocation factor (PAF) for what portion of those emissions are allocated to soy based on soy expansion in Brazil from 2005–2006, and the linear amortization factor of 0.25 percent since 2006 is year 20 of the LUC assessment period (i.e., 19 years prior to the reporting year). They would apply a similar calculation for each year up to 2025, sum the resulting LUC emissions allocated to soy in Brazil over that LUC assessment period, then divide those LUC emissions by the total Brazilian soy production in 2025 to determine the sLUC emission factor for Brazilian soy in 2025.

Equation 7.6 Calculate the statistical land use change (sLUC) emission factor

$$EF\_sLUC_{k,a} = \frac{\sum_{yLUC=1}^{AP}\left(GHG\_LUC_{a,yLUC} \times PAF\_PE_{a,k,yLUC} \times LAF_{yLUC}\right)}{P_{a,k}}$$

Description		Unit	Source
$EF\_sLUC_{k,a}$	Statistical land use change (sLUC) emissions factor for product *k*, in assessment area a, in the inventory reporting year	tonnes GHG (tonne product) $^{-1}$	Calculated
$GHG\_LUC_{a,yLUC}$	GHG emissions (GHG) from land use change in assessment area *a* in the company's value chain, in year *yLUC* of the LUC assessment period	tonnes GHG	Equation 7.1
LAF_{yLUC}	Linear amortization factor (LAF) for year *yLUC* of the LUC assessment period	dimensionless	Table 7.11, Equation 7.5
$PAF\_PE_{a,k,yLUC}$	Product allocation factor (PAF) using the product expansion (PE) allocation method in assessment area a, for product *k*, sourced in year *yLUC* of the LUC assessment period; the product expansion allocation method is required (see Section 7.4.6)	dimensionless	Equation 7.3
$P_{a,k}$	Total production in assessment area a of product *k*, in the inventory reporting year	tonnes	User input
$yLUC$	Year in the LUC assessment period		Table 7.11
AP	Number of years in the LUC assessment period	year	User input (Requirement 10)
k	Product produced in assessment area a		User input
a	Assessment area (i.e., all lands in the global, jurisdiction, or sourcing region scope 3 spatial boundary)		User input

STEP 5: CALCULATE TOTAL PRODUCT SLUC EMISSIONS

Using Equation 7.7, multiply the total quantity of product (*k*) sourced by the reporting company from a given assessment area (*a*) in the reporting year, by the sLUC emission factor produced in Equation 7.6. This results in the total sLUC emissions in the assessment area (*a*) attributable to product (*k*) in the reporting year.

Equation 7.7 Total product sLUC emissions

$$sLUC_{k,a} = Q_{k,a} \times EF\_sLUC_{k,a}$$

Description		Unit	Source
$sLUC_{k,a}$	Total statistical land use change (sLUC) emissions attributable to product *k* sourced by the reporting company from assessment area *a*, in the inventory reporting year	tonnes GHG	Calculated
$Q_{k,a}$	Quantity of product *k* sourced by the reporting company from assessment area *a*, in the inventory reporting year	tonnes or m^3 product	User input
$EF\_sLUC_{k,a}$	Statistical land use change (sLUC) emissions factor for product *k*, in assessment area *a*, in the inventory reporting year	tonnes GHG (tonne product) $^{-1}$	Equation 7.6
k	Product produced in assessment area *a*		User input
a	Assessment area (i.e., all lands in the global, jurisdiction, or sourcing region scope 3 spatial boundary)		User input

7.5.3.2 Calculating LUC emissions using the jurisdictional direct land use change calculation approach

When companies have traceability to a jurisdiction or sourcing region level and the necessary data is available to implement a jurisdictional dLUC (jdLUC) calculation approach (see Table 7.8), companies should apply the jdLUC calculation approach. An overview of the steps for calculating scope 3 jdLUC emissions using the jdLUC calculation approach is shown in Table 7.12. Note that steps 1–5 in Table 7.12 are the same general steps as in Table 7.13 to calculate LMU-level dLUC emissions.

Table 7.12 Overview of steps of the jdLUC calculation approach

Step	Reference
Step 1: Calculate total jdLUC emissions on all attributable productive land in the sourcing area that occurred in each year of the LUC assessment period	**Equation 7.1, Equation 7.2**
Step 2: Using linear amortization, amortize jdLUC emissions across the LUC assessment period	**Table 7.11, Equation 7.5**
Step 3 (if applicable): Allocate jdLUC emissions across outputs of the cropping system	**Section 6.4.5**
Step 4: Calculate the jdLUC emission factor	**Equation 7.8**
Step 5: Calculate total product jdLUC emissions	**Equation 7.9**
Step 6: Calculate total scope 3 dLUC emissions	

STEP 1: CALCULATE TOTAL JDLUC EMISSIONS ON ALL ATTRIBUTABLE PRODUCTIVE LAND IN THE SOURCING AREA THAT OCCURRED IN EACH YEAR OF THE LUC ASSESSMENT PERIOD

By combining spatial land use/land cover data for years in the LUC assessment period with a crop-extent map of all attributable productive lands in the reporting year, companies can detect annual LUC and quantify total LUC emissions that occurred on attributable productive lands in each year of the LUC assessment period. Companies use Equations 7.1 and 7.2 in Section 7.5.3.1, but where LUC emissions are only calculated on attributable productive land associated with a given product (*k*) that a company sources within a given assessment area (*a*). To ensure complete and consistent coverage of all agricultural land use in the scope 3 spatial boundary, companies should seek maps or other spatial data that identify attributable productive lands for *all* agricultural products produced in the sourcing area in the reporting year (e.g., MapBiomas data on crop land cover and land use areas in Brazil). Where such data for all crops is not available, companies may use spatial data for attributable productive land specific to the crop or other sourced product of interest.

For example, for a company that sources cocoa from Ghana that is applying a jurisdictional dLUC calculation approach, LUC emissions would be calculated for all lands producing cocoa in Ghana where deforestation or conversion occurred within the LUC assessment period, based on spatial data from land use change and cocoa maps. This approach differs from an sLUC approach, which would instead estimate LUC emissions for *all* lands in Ghana where deforestation or conversion occurred within the LUC assessment period (and then those LUC emissions would be allocated to cocoa and other products grown in Ghana using product allocation factors based on statistical data).

STEP 2: USING LINEAR AMORTIZATION, AMORTIZE JDLUC EMISSIONS ACROSS THE LUC ASSESSMENT PERIOD

Companies should follow the same instructions in Step 3 in Section 7.5.3.1.

The required amortization method for LUC emissions accounting in this *Standard* is linear amortization. When using linear amortization to distribute LUC impacts across the LUC assessment period, companies need to first estimate LUC for each year in the LUC assessment period occurring on attributable productive lands in the sourcing area. They then can multiply the LUC emissions for each year by a linear amortization factor corresponding to each year of the LUC assessment period. Table 7.11 and Equation 7.5 (used to calculate the LAFs for LUC assessment periods greater than 20 years) define the linear amortization factor (LAF) that is applied, as shown in Equation 7.8.

STEP 3: ALLOCATE JDLUC EMISSIONS ACROSS OUTPUTS OF CROPPING SYSTEM (IF APPLICABLE)

Allocation is the process of partitioning GHG emissions, removals, or other metrics from a single system among its various outputs. If applicable, jdLUC emissions may need to be allocated across the multiple outputs of a cropping system (e.g., multiple crops are commonly produced on the same attributable productive land area through crop rotations, intercropping, etc.). Companies should apply the agricultural allocation recommendations and guidance in Chapter 6 of the *Standard* and Section 6.4.5 of the *Guidance* to allocate jdLUC emissions on land areas known to produce multiple agricultural products within the sourcing area.

STEP 4: CALCULATE THE JDLUC EMISSION FACTOR

Equation 7.8 is used to calculate the jdLUC emission factor.

Equation 7.8 Calculate the jurisdictional land use change (jdLUC) emission factor

$$EF\_jdLUC_{k,a} = \frac{\sum_{yLUC=1}^{AP}\left(GHG\_LUC_{a,yLUC} \times LAF_{yLUC}\right)}{P_{a,k}}$$

Description		Unit	Source
$EF\_jdLUC_{k,a}$	Jurisdictional direct land use change (jdLUC) emissions factor for product *k*, sourced from assessment area *a*, in the inventory reporting year	tonnes GHG (tonne product) $^{-1}$	Calculated
$GHG\_LUC_{a,yLUC}$	GHG emissions (GHG) from LUC on attributable productive lands in the assessment area *a*, in year *yLUC* of the LUC assessment period	tonnes GHG	Equation 7.1
LAF_{yLUC}	Linear amortization factor for year *yLUC* of the LUC assessment period	dimensionless	Table 7.11, Equation 7.5
$P_{a,k}$	Total production in assessment area *a* of product *k*, in the inventory reporting year	tonnes	User input
$yLUC$	Year in the LUC assessment period		Table 7.11
AP	Number of years in the LUC assessment period	year	User input (Requirement 10)
k	Product produced in assessment area *a*		User input
a	Assessment area (i.e., all attributable productive lands in the jurisdiction or sourcing region scope 3 spatial boundary)		User input

STEP 5: CALCULATE TOTAL PRODUCT JDLUC EMISSIONS

Using Equation 7.9, multiply the total quantity of product *k* sourced from a given assessment area (*a)* in the reporting year by the jdLUC emission factor produced in Equation 7.8. This results in the total jdLUC emissions in the assessment area (*a*) attributable to product (*k*) in the given reporting year.

Equation 7.9 Total product jdLUC emissions

$$jdLUC_{k,a} = Q_{k,a} \times EF\_jdLUC_{k,a}$$

Description		Unit	Source
$jdLUC_{k,a}$	Total jurisdictional direct land use change (jdLUC) emissions attributable to product *k* sourced by the reporting company from assessment area *a*, in the inventory reporting year	tonnes GHG	Calculated
$Q_{k,a}$	Quantity of product k sourced by the reporting company from assessment area *a*, in the inventory reporting year	tonnes or m^3 product	User input
$EF\_jdLUC_{k,a}$	Jurisdictional direct land use change (jdLUC) emissions factor for product *k*, sourced from assessment area *a*, in the inventory reporting year	tonnes GHG (tonne product) $^{-1}$	Equation 7.8
k	Product produced in assessment area *a*		User input
a	Assessment area (i.e., all attributable productive lands in the jurisdiction or sourcing region scope 3 spatial boundary)		User input

STEP 6: CALCULATE TOTAL SCOPE 3 DLUC EMISSIONS

Jurisdictional and LMU-level dLUC calculation approaches are methodologically compatible; therefore, companies can combine both calculation approaches to account for scope 3 LUC emissions for a given product type by sourcing jurisdiction.

Statistical LUC and direct LUC calculation approaches are not methodologically compatible; therefore, companies cannot combine sLUC and dLUC calculation approaches to account for scope 3 LUC emissions for a given product type by sourcing jurisdiction. Using separate calculation approaches by product type and jurisdiction is especially important to support the use of the GHG inventory to track progress towards climate targets (see Requirements 10 and 28 on re-baselining to ensure consistent LUC emission calculation methods over time). However, when reporting total scope 3 LUC emissions, companies may add sLUC and dLUC values for different product types by sourcing jurisdiction.

For example, a company that sources coffee from Brazil, Colombia, and Ecuador may choose to apply a dLUC calculation approach for the coffee they source from Brazil, where they may have relatively more complete LUC and coffee production maps and more granular traceability to individual coffee plantations. The company might apply an sLUC calculation approach for the coffee they source from Colombia and Ecuador, where they do not have the complete spatial data on coffee production for the whole country of origin needed to apply a jdLUC approach.

Even if the reporting company has plantation-level data to estimate LMU-level dLUC emissions for some coffee plantations they source from in Colombia, the reporting company cannot use this data in an LMU-level dLUC calculation approach and account for the remaining coffee sourced from Colombia using an sLUC calculation approach, as these two methodologies are not compatible. Instead, the reporting company must apply the same calculation approach (i.e., either sLUC or dLUC) to complete the LUC emissions accounting for a given product by sourcing jurisdiction. However, when reporting total scope 3 inventory LUC emissions from all sourced coffee, the reporting company may add the dLUC emissions estimates from Brazilian-sourced coffee with the sLUC emissions estimates from Colombia and Ecuador, because they are from different sourcing jurisdictions.

Case study: Mars—Jurisdictional dLUC calculation approach

CALCULATING CONSISTENT LUC EMISSION FACTORS ACROSS DIFFERENT LEVELS OF TRACEABILITY

Mars, Incorporated—a global, family-owned business with a diverse and expanding portfolio of leading pet care products and veterinary services, and quality snacking and food products—is transforming and innovating in alignment with its "Sustainable in a Generation" plan.

Mars partnered with data solution provider AdAstra Sustainability to consistently account for land conversion emissions from soy in poultry feed at varying levels of traceability. Using a novel jurisdictional dLUC approach, they derived LUC emission factors that significantly improved the accuracy of the poultry's carbon footprint.

MARS' CHALLENGE

The complexity of the soy value chain makes it challenging to identify the origins of the crop at a land management unit (LMU) level. This is especially true when soy is an indirect ingredient, embedded in a product such as poultry, via animal feed.

In the absence of the soy's farm-level origins, and sometimes in the absence of any information beyond poultry slaughterhouse locations, Mars sought an alternative to sLUC to more accurately measure their embedded soy's LUC emissions. A new approach would need to overcome the gaps in traceability.

THE SOLUTION

Using their technology, Orbae, AdAstra wove together spatially explicit crop masks, carbon stock data, and land conversion history into a fabric of LUC emission factors that represented a country's soy production at 30-meter resolution. The calculation considered all carbon pools and all types of land conversion to soy cultivation, using linear amortization to allocate the LUC emissions of the previous 20 years to the reporting year. Unlike traditional LMU-level dLUC, which works with farm polygons and therefore requires full traceability, jurisdictional dLUC calculates emissions at the landscape level, capturing the dLUC emissions of a commodity grown in any given jurisdiction or sourcing region according to the level of traceability available.[a]

AdAstra then aggregated the 30 m cells of emission factors to meet the most granular level of traceability Mars had, such as the jurisdiction or sourcing region of soybean crushers and silos. To set a sourcing region-level scope 3 spatial boundary, companies must establish physical traceability to the first point of collection (e.g., a grain silo).

OUTCOMES

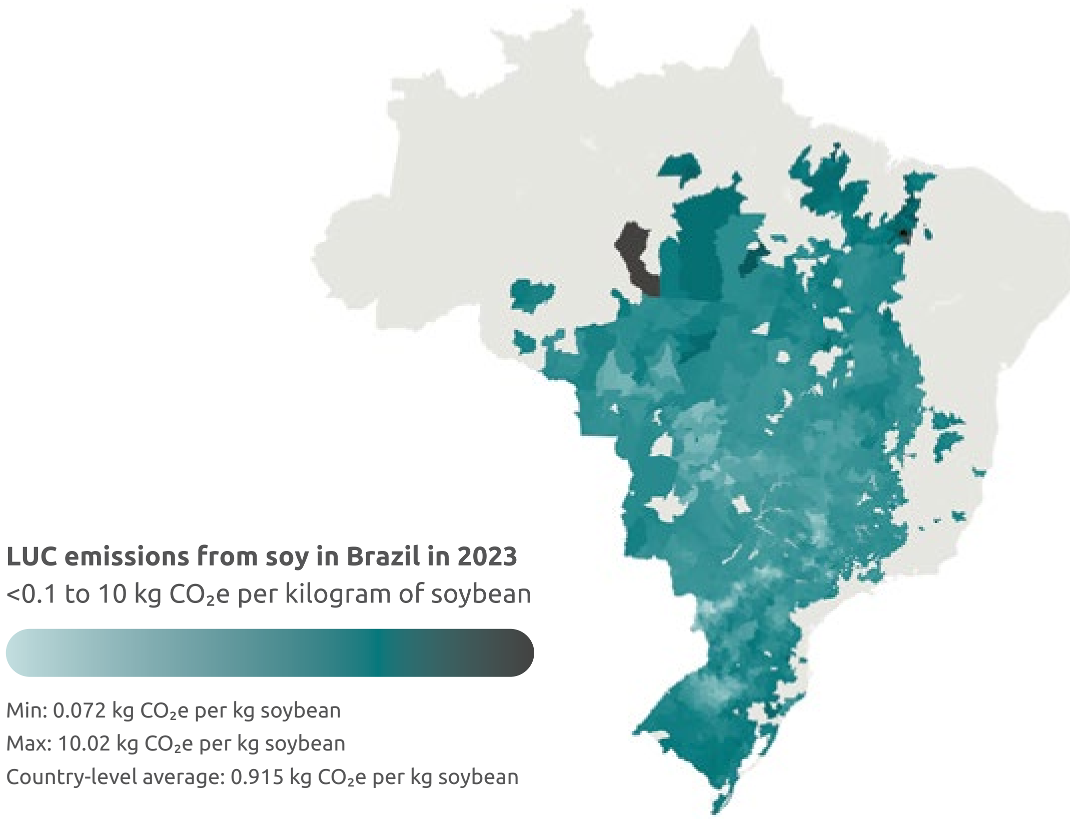
The spatially explicit assessment revealed jurisdictional dLUC emission factors for soy that differed from country-level sLUC factors in common LCI databases by up to a factor of 10.

Jurisdictional dLUC enables companies along agricultural value chains to improve multiple aspects of their decision making by:

- Evaluating land conversion impacts consistently at any level of traceability, avoiding over- or under-claiming reductions.
- Setting a robust LUC baseline to inform a credible climate strategy.
- Prioritizing interventions and tracking their effectiveness.
- Understanding the trajectory of their LUC footprint over time.

Case study: Mars—Jurisdictional dLUC calculation approach (cont.)

With better baseline data from jurisdictional dLUC, Mars can effectively design strategies to stop deforestation and conversion and reduce LUC emissions. Regardless of the direction of the change to the base-year emissions, higher-quality data help to ensure that resources and strategies are designed optimally to contribute to climate action.



Note: LUC emissions by municipality for soy produced in Brazil in 2023. Using a jurisdictional dLUC calculation approach, the carbon footprint ranged from less than 0.1 to more than 10 kg CO_2e per kilogram of soybeans, with a country-level average of 0.915 kg CO_2e per kilogram. Municipalities that produced less than 40 ha of soybeans (i.e., outliers) have been removed for clarity.

Note: a. See how sLUC, jdLUC, and dLUC compare at AdAstra Sustainability. Explore jurisdictional dLUC emission factors at orbae.
b. Disclaimer: The GHG Protocol has not reviewed and does not endorse resources shared outside of this text box.

7.5.3.3 Calculating LUC emissions using the land management unit (LMU)-level direct land use change calculation approach

When companies calculate scope 1 LUC emissions, or have complete traceability to a specific land management unit(s) when accounting for scope 3 LUC emissions, companies should apply the LMU-level dLUC calculation approach. Companies that calculate scope 1 LUC emissions on land that they own or control follow Steps 1 and 2 below, as represented in Equation 7.10. Note that when accounting for scope 1 LUC emissions, allocation of emissions across products is not necessary (i.e., Steps 3–5 below are not applicable). When accounting for scope 3 LUC emissions, and when companies have complete traceability to the land management unit (LMU) in their value chain, companies should follow Steps 1–6 below. An overview of the steps for calculating LMU-level dLUC emissions using the LMU-level LUC calculation approach is shown in Table 7.13.

Table 7.13 Overview of steps of the LMU-level dLUC calculation approach

Step	Scope 1 or 3 accounting?	Reference
Step 1: Calculate total LMU-level dLUC emissions that occurred within the LMU in each year of the LUC assessment period	Scope 1 & 3	**Equation 7.10, Equation 7.1**
Step 2: Using linear amortization, amortize LMU-level dLUC emissions across the LUC assessment period	Scope 1 & 3	**Table 7.11, Equation 7.5**
Step 3 (if applicable): Allocate LMU-level dLUC emissions across outputs of the cropping system	Scope 3	**Section 6.4.5**
Step 4: Calculate the LMU-level dLUC emission factor	Scope 3	**Equation 7.11**
Step 5: Calculate total product LMU-level dLUC emissions	Scope 3	**Equation 7.12**
Step 6: Calculate total scope 3 dLUC emissions	Scope 3	

STEP 1: CALCULATE TOTAL LMU-LEVEL DLUC EMISSIONS WITHIN KNOWN LMU(S) THAT OCCURRED IN EACH YEAR OF THE LUC ASSESSMENT PERIOD

Companies use Equation 7.10 to quantify total LUC emissions that occurred on lands owned or controlled by the reporting company or lands in LMU(s) in the company's value chain, in each year of the LUC assessment period. Total LMU-level dLUC emissions occurring in each year of the LUC assessment period are amortized, as explained in Step 2.

STEP 2: USING LINEAR AMORTIZATION, AMORTIZE LMU-LEVEL DLUC EMISSIONS ACROSS THE LUC ASSESSMENT PERIOD.

Companies should follow the same instructions as in Step 3 in Section 7.5.3.1.

The required amortization method for LUC emissions accounting in this *Standard* is linear amortization. When using linear amortization to distribute LUC impacts across the LUC assessment period, companies need to first estimate LUC within the LMU for each year in the LUC assessment period. They then can multiply the LUC emissions for each year by a linear amortization factor corresponding to each year of the LUC assessment period. Table 7.11 and Equation 7.5 are used to identify the correct linear amortization factor (LAF) (for LUC assessment periods equal to or greater than 20 years, respectively) that is applied to amortize LUC emissions occurring in each year of the LUC assessment period, as shown in Equation 7.10.

Equation 7.10 Total LMU-level direct land use change emissions

$$\text{Scope 1:} \quad dLUC_a = \sum_{yLUC=1}^{AP}\left(GHG\_LUC_{a,yLUC} \times LAF_{yLUC}\right)$$

$$\text{Scope 3:} \quad dLUC\_LMU_{k,a} = \sum_{yLUC=1}^{AP}\left(GHG\_LUC_{a,yLUC} \times LAF_{yLUC}\right)$$

Description		Unit	Source
$dLUC_a$	Total, amortized LMU-level direct LUC emissions attributable to land management unit *a* in the inventory reporting year	tonnes GHG	Calculated
$dLUC\_LMU_{k,a}$	Amortized LMU-level direct land use change emissions allocated* to product *k*, sourced from known LMU *a* in the inventory reporting year	tonnes GHG	Calculated
$GHG\_LUC_{a,yLUC}$	Direct LUC emissions on land management unit *a* in year *yLUC* of the LUC assessment period	tonnes GHG	Equation 7.1
LAF_{yLUC}	Linear amortization factor for year *yLUC* of the LUC assessment period	dimensionless	Table 7.11, Equation 7.5
$yLUC$	Year in the LUC assessment period		Table 7.11
AP	Number of years in the LUC assessment period	year	User input (Requirement 10)
k	Product produced in assessment area *a*		User input
a	Assessment area (i.e., all productive lands in the LMU boundary)		User input

Note: *Allocation across outputs from the LMU may be necessary but is not explicitly shown in this equation. See Step 3 in Section 7.5.3.3 for allocation guidance.

STEP 3: ALLOCATE LMU-LEVEL DLUC EMISSIONS ACROSS OUTPUTS OF THE CROPPING SYSTEM (IF APPLICABLE)

Allocation is the process of partitioning GHG emissions, removals, or other metrics from a single system among its various outputs. Where LMUs produce multiple agricultural products and are unable to collect data at the field level for each product, LMU-level dLUC emissions may need to be allocated across the multiple outputs of a cropping system. When implementing an LMU-level dLUC emission calculation approach, a company must have traceability to specific LMUs of origin, and thus, the cropping system (if any) in the product's life cycle can be identified. Companies should aim to work with suppliers to identify relevant cropping systems with multiple outputs that may require allocation.

Chapter 6 in the *Standard* provides recommendations for allocating across outputs of cropping systems in the agricultural sector, and Section 6.4.5 in the *Guidance* provides additional allocation guidance.

STEP 4: CALCULATE THE LMU-LEVEL DLUC EMISSION FACTOR

Equation 7.11 is used to calculate the LMU-level dLUC emission factor.

Equation 7.11 Calculating the LMU-level direct land use change emission factor

$$EF\_dLUC_{k,a} = \frac{dLUC\_LMU_{k,a}}{P_{k,a}}$$

Description		Unit	Source
$EF\_dLUC_{k,a}$	LMU-level direct LUC emission factor for product *k* sourced from known LMU *a*, in the reporting year	tonne GHG (tonne product)$^{-1}$	Calculated
$dLUC\_LMU_{k,a}$	Amortized LMU-level direct land use change emissions allocated* to product *k*, sourced from known LMU *a* in the inventory reporting year	tonnes GHG	Equation 7.10
$P_{k,a}$	Total production of product *k* produced in known LMU *a* in the reporting year	tonnes	User input
k	Product produced in assessment area *a*		User input
a	Assessment area (i.e., all productive lands in the LMU boundary)		User input

Note: *Allocation across outputs from the LMU may be necessary but is not explicitly shown in this equation. See Step 3 in Section 7.5.3.3 for allocation guidance.

STEP 5: CALCULATE TOTAL PRODUCT LMU-LEVEL DLUC EMISSIONS

Using Equation 7.12, multiply the total quantity of product (*k)* sourced from a given LMU in the reporting year by the LMU-level dLUC emission factor produced in Equation 7.11.

Equation 7.12 Total product dLUC emissions

$$dLUC_{k,a} = Q_{k,a} \times EF\_dLUC_{k,a}$$

Description		Unit	Source
$EF\_dLUC_{k,a}$	Total LMU-level direct land use change (dLUC) emissions attributable to sourced product *k* produced on LMU *a* in the inventory reporting year	tonnes GHG	Calculated
$dLUC\_LMU_{k,a}$	Quantity of product sourced from LMU *a*, by product type *k*, in the inventory reporting year	tonnes or m^3 product	User input
$P_{k,a}$	Direct LMU-level land use change emissions factor for product *k* sourced from known LMU *a* in the reporting year	tonne GHG (tonne product)$^{-1}$	Equation 7.11
k	Product produced in assessment area *a*		User input
a	Assessment area (i.e., all productive lands in the LMU boundary that produced product *k*)		User input

STEP 6: CALCULATE TOTAL SCOPE 3 DLUC EMISSIONS

Companies should follow the same instructions in Step 6 in Section 7.5.3.2.

Because LMU-level and jurisdictional dLUC calculation approaches are methodologically compatible, companies can combine jurisdictional and LMU-level dLUC calculation approaches to complete the scope 3 LUC emissions accounting for a product type by sourcing jurisdiction.

7.5.3.4 Calculating water reservoir LUC emissions

To estimate CO_2 emissions from water reservoirs and other flooded lands, companies can apply Equation 7.13 using IPCC Tier 1 emission factors[19] and associated activity data, or can apply a higher-tier approach. All CO_2 emissions emitted from the water reservoir during the 20-year assessment period are accounted for as LUC emissions. The 20-year assessment period begins at the LUC event (i.e., the flooding of the land to create the water reservoir). Note that CO_2 emissions from water reservoirs are not time-amortized across the assessment period.

To calculate LUC CO_2 emissions from water reservoirs using a Tier 1 approach, companies use Equation 7.13, which is adapted from the IPCC's *2019 Refinement*. The Tier 2 methodology for estimating Tier 2 LUC CO_2 from water reservoirs (<20 years old) uses Equation 7.13, substituting in the emission factor calculated using the relevant Tier 2 factor in the *2019 Refinement*.

Equation 7.13 CO_2 emissions from water reservoirs

$$CO2\_WR_{w,z} = A_{w,z} \times EF\_CO2_z$$

Description		Unit	Source
$CO2\_WR_{w,z}$	CO_2 emissions from water reservoir *w* in climate zone *z*, in inventory reporting year	tonnes CO_2 (year)$^{-1}$	Calculated
$A_{w,z}$	Total flooded surface area for water reservoir *w* in climate zone *z*, in inventory reporting year	ha	User input
EF_CO2_z	Emission factor for CO_2 for reservoirs ≤20 years old in climate zone *z*	tonnes CO_2 (hectare)$^{-1}$ (year)$^{-1}$	Default value or user input
z	Climate zone		User input
w	Water reservoir		User input

Source: Adapted from IPCC (2019a), Volume 4: Agriculture, Forestry and Other Land Use; Chapter 7 Wetlands; Equation 7.13 and Table 7.13.

To estimate methane emissions from water reservoirs and other flooded lands, companies can apply Equation 7.14 using IPCC Tier 1 emission factors[20] and associated activity data, or can apply a higher-tier approach. When estimating methane emissions from water reservoirs, companies should use emission factors that are specific to water reservoir age and climate. All methane emissions from land converted to a water reservoir during a 100-year assessment period (beginning at the construction of the water reservoir) are accounted for as land use change emissions. Note that methane emissions from water reservoirs are not time-amortized across the assessment period.

To calculate LUC CH_4 emissions from water reservoirs using a Tier 1 approach, companies use Equation 7.14, which is adapted from the IPCC's *2019 Refinement*. Using a Tier 1 approach, companies select a CH_4 emission factor based on the years elapsed since the creation of the water reservoir (≤20 years or >20 years) and the relevant climate zone where the reservoir exists.

For example, using a Tier 1 approach, methane emission factors corresponding to the first 20 years post-land use change are used to account for elevated methane emissions in this time period; separate methane emission factors corresponding to the 20- to 100-year age range of the water reservoir are used to account for the stable methane flux during this time period. Companies should refer to Sections 7.3.2.1 and 7.3.2.2 in the *2019 Refinement* for further calculation guidance.

Equation 7.14 CH_4 emissions from water reservoirs and other flooded land

$$CH4\_WR_{w,z} = A_{w,z} \times EF\_CH4_{f,z} \times (\alpha + RD)$$

Description		Unit	Source
$CH4\_WR_{w,z}$	CH_4 emissions from water reservoir *w* in climate zone *z*, in inventory reporting year	kg CH_4 $(year)^{-1}$	Calculated
$A_{w,z}$	Total flooded surface area for water reservoir *w* in climate zone *z*, in inventory reporting year	ha	User input
$EF\_CH4_{f,z}$	Emission factor for CH_4 for reservoirs in age class *f* in climate zone *z*	kg CH_4 $(hectare)^{-1}$ $(year)^{-1}$	Default value or user input
RD	Ratio of total downstream CH_4 emissions to the total flux of CH_4 from the reservoir surface. Equals 0.09 by default for Tier 1.	kg CH_4 downstream (kg CH_4 from reservoir)$^{-1}$	Default value
α	Emission factor adjustment for trophic state in reservoir *w* within a given climate zone *z*, dimensionless. Equals 1.0 by default for Tier 1.	dimensionless	User input
z	Climate zone		User input
f	Reservoir age class (i.e., ≤20 years and >20 years)		IPCC subcategory
w	Water reservoir		User input

Source: Adapted from IPCC (2019a), Volume 4, Agriculture, Forestry and Other Land Use; Chapter 7 Wetlands; Equations 7.15 and 7.10, and Tables 7.9 and 7.15.

To pursue a Tier 3 approach, companies can use a model of water reservoir-specific methane emission rates, such as the GHG Reservoir Tool (G-res) model, direct measurements, or a combination thereof.[21] Activity data on the total flooded surface area should be based on operations or management records on lands used for reservoirs or other flood lands, and correspond to fine spatial and temporal scales. Companies should include drawdown zones or induction areas in the total flooded surface area used to calculate methane emissions. For scope 3 accounting, where such data is not available, companies can use data on the average surface area of reservoirs in the region or country, which should be available from national statistics services such as environmental agencies or peer-reviewed research on the extent of reservoirs or other flooded lands. As recommended in Section 6.3 in the

Standard, and discussed in Section 6.4.4.3 in the *Guidance*, companies should be careful to calibrate models using empirical data specific to the land area, management practices, and GHG impacts (i.e., carbon stock changes or GHG emissions) under analysis.

When estimating methane emissions from "other constructed water bodies," companies should use emission factors specific to freshwater ponds, saline ponds, canals, or ditches, and do not need to estimate downstream methane emissions (i.e., apply a default of zero for the ratio of total downstream CH_4 emissions). Companies can also scale emission factors to better reflect decomposition rates if information about the average annual chlorophyll-a concentration value is available. For more further guidance on emission factor selection for other constructed water bodies and chlorophyll-a scaling, see Chapter 7 in Volume 4 of the IPCC's *2019 Refinement*.[22]

Endnotes

1 This text includes elements that may change to align with the resolution on forest carbon accounting in future versions of this *Standard*. See Box 9.1.

2 See the Accountability Framework Initiative (AFi) for further guidance on conversion from natural ecosystems.

3 As set forth in Requirement 10, to account for forest subcategory LUC emissions, a company must first account for subcategory LUC CO_2 emissions based on the gross initial land carbon stock decrease across all land carbon pools due to the subcategory LUC. Accounting for land management CO_2 removals due to regrowth and management of plantation forests is subject to the resolution on forest carbon accounting in future versions of this *Standard*. See Box 9.1.

4 Definition adapted from FAO (2018).

5 See the Accountability Framework Initiative (AFi) for relevant definitions and further guidance on conversion from natural ecosystems.

6 As set forth in Requirement 10, to account for forest subcategory LUC emissions, a company must first account for subcategory LUC CO_2 emissions based on the gross initial land carbon stock decrease across all land carbon pools due to the subcategory LUC. Accounting for land management CO_2 removals due to regrowth and management of forests, including natural and plantation forests, is not covered in version 1 of this *Standard* (see Boxes 1.1 and 9.1).

7 See the Accountability Framework Initiative (AFi) for relevant definitions and further guidance on conversion from natural ecosystems.

8 IPCC 2019a.

9 IPCC 2014.

10 IPCC 2014.

11 IPCC (2006) and IPCC (2003).

12 Used for demonstration only; 25 years has been cited as the average economic lifespan of a commercial oil palm plantation (see, e.g., Petri et al. 2024).

13 Such LUC emissions from water reservoirs are associated with the life cycle of hydropower facilities and are accounted for in scope 3. These emissions are not directly associated with the generation of purchased electricity, which are accounted for in scope 2.

14 See https://www.hs-alliance.org/hs-standard.

15 IPCC 2019a; Volume 4, Chapter 7, Table 7.13.

16 IPCC 2019a; Volume 4, Chapter 7, Tables 7.15 and 7.9.

17 IPCC 2019a; Volume 4, Chapter 7.

18 AFi 2024.

19 IPCC 2019a; Volume 4, Chapter 7, Table 7.13.

20 IPCC 2019a; Volume 4, Chapter 7, Tables 7.15 and 7.9.

21 Available at https://g-res.hydropower.org

22 IPCC 2019a; Volume 4, Chapter 7.

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