CHAPTER 6.

Data and methods

This chapter provides requirements and recommendations on collecting data, quantification methods, scope 3 allocation, and uncertainty. These topics are further elaborated in the Guidance.

6.1 Overview

A variety of methods and data sources are available to quantify land sector GHG emissions, CO_2 removals, and other metrics. Methodological decisions should be made based on a combination of factors, including data and method availability, the company's location within the value chain and level of traceability, and the additional data requirements for removals accounting (Chapter 12). Quantifying emissions and removals from specific practices occurring within a company's operations and value chain requires data and methods specific to the relevant lands and land management practices.

All companies must use the same allocation methods across metrics (Requirement 9).

All companies must report:

- Information on the data sources, methods, and assumptions used to develop their inventory by meeting the data and methods reporting requirement in Section 6.2.2 (See "Reporting GHG inventory data and methods").
- Additional information specific to each accounting subcategory is provided in each subsequent chapter, as an elaboration of the reporting requirement in this chapter. These additional reporting requirements are provided in Section [X].2.2 of each subsequent chapter (e.g., Reporting requirements for land use change emissions are provided in Chapter 7, Section 7.2.2).

All companies are encouraged (see Recommendations in Section 6.3) to:

- Aim for higher accuracy data and methods, evaluate data quality, and improve their inventory over time.
- Calibrate models using empirical data.
- Disclose if metrics within the inventory are non-comparable within the organization.
- Allocate emissions, removals, and other metrics to multiple outputs of a process in a way that best reflects the causal relationship between the production of the outputs and the resulting emissions, removals, or other metrics.

6.2 Requirements

6.2.1 Accounting requirements

REQUIREMENT 9:

Same allocation methods across metrics

Companies **shall** apply the same allocation method across accounting categories (i.e., emissions, removals, and other metrics) within a given spatial boundary.

6.2.2 Reporting requirements

Reporting GHG inventory data and methods

Companies **shall** disclose in their GHG report:

- **Data and methods**: For each scope, scope 3 category, and accounting subcategory, companies **shall** describe:
  - Methodologies, scope 3 allocation methods, and assumptions used to calculate emissions, removals, or other metrics.
  - Types and sources of data (e.g., activity data, emissions factors, carbon opportunity cost factors, conversion factors, and GWP values) used to calculate emissions, removals, and other metrics.
  - Data quality of reported data, including, if applicable, sampling method(s) used and uncertainty of the results, with methodology (if quantitative) or description (if qualitative).
- **Share of supplier-specific data**: For each scope 3 category, companies **shall** disclose the percentage of emissions calculated using data obtained from suppliers or other value chain partners.
- **Spatial boundaries**: Companies **shall** describe:
  - Scope 1 spatial boundary: the spatial boundary for lands owned or controlled by the company.
  - Scope 3 spatial boundary: the level of traceability and spatial scale used (i.e., harvested area, LMU, sourcing region, jurisdiction, global), by a given volume of a given product (e.g., crops, animal products, bioenergy feedstock, etc.) or other specific scope 3 activity (e.g., certain leased lands or investments). The description **should** include a summary of the LMUs and/or attributable productive lands included in the spatial boundary.[1]
  - If applicable, the type of chain-of-custody model and/or certification program used to demonstrate traceability (described in Requirement 8).
- **Use of aggregated data**: If companies use aggregated data to report emissions, removals, or other metrics that are required to be disaggregated by accounting subcategory (see Requirement 32), they **shall** justify how the accounting category (or categories) comprise a small share of the total GHG inventory.
- **Evidence for recycled waste**: If companies use the recycled content allocation method for post-consumer waste that is recycled or reused, companies **shall** provide evidence that the waste is post-consumer and that the waste has been reused or recycled.

See additional reporting requirements in Section [X].2.2 of each chapter for additional reporting information on each accounting subcategory or topic.

6.3 Recommendations

Higher accuracy data and methods

Companies **should** prioritize using higher accuracy methods and reduce uncertainty as far as is practical. Companies **should** collect supplier-specific data for the GHG sources and sinks that are most significant (i.e., comprise the greatest share of the inventory) across their operations and value chain and/or where the opportunity for emissions reduction and removals enhancements is greatest. Companies **should** improve their data collection over time to increase the accuracy of their reported GHG emissions, removals, land use, and leakage, and additional accounting categories by gathering more supplier-specific data, evaluating and improving data quality, and prioritizing data and methods that reduce uncertainty, as relevant to meeting their specific business goals.

See the Guidance (Chapter 6) and Scope 3 Standard for additional information on evaluating data quality and uncertainty.

Model calibration and validation recommendation

Companies **should** calibrate model-based and remote sensing-based calculation approaches using empirical data specific to the land area, management practices, and GHG impacts (i.e., carbon stock changes or GHG emissions) under analysis. Companies **should** report a description of the process undertaken to calibrate the model, including reference to the data used to calibrate the model and its applicability to the GHG impacts being estimated.

Disclosing internal non-comparability

Companies **should** disclose and justify if the emissions, removals, or other land-related metrics within their inventory are not comparable across each of their products, business units, and/or regions due to differences in methods and/or data used for each.

Scope 3 allocation recommendations

In most product life cycles, there is at least one common process that has multiple products as outputs, and for which it is not possible to collect data at the individual output level. In these situations, the total emissions, removals, and other metrics from the common process need to be partitioned among the multiple outputs (see Requirement 9). The most appropriate allocation method for a given process depends on the specific circumstances of the process (see Section 6.4.5 in the *Guidance* for additional details). Different allocation methods may yield significantly different results.

As a general principle, companies **should** select the allocation method that:

- best reflects the causal relationship between the production of the outputs and the resulting emissions, removals, and other metrics, either because:
  - the physical properties of the product and co-products determine the emissions, removals, and other metrics of the process; or
  - the demand for a product or co-product determines the emissions, removals, and other metrics of the common process.
- results in the most accurate and credible emissions, removals, and other metrics estimates

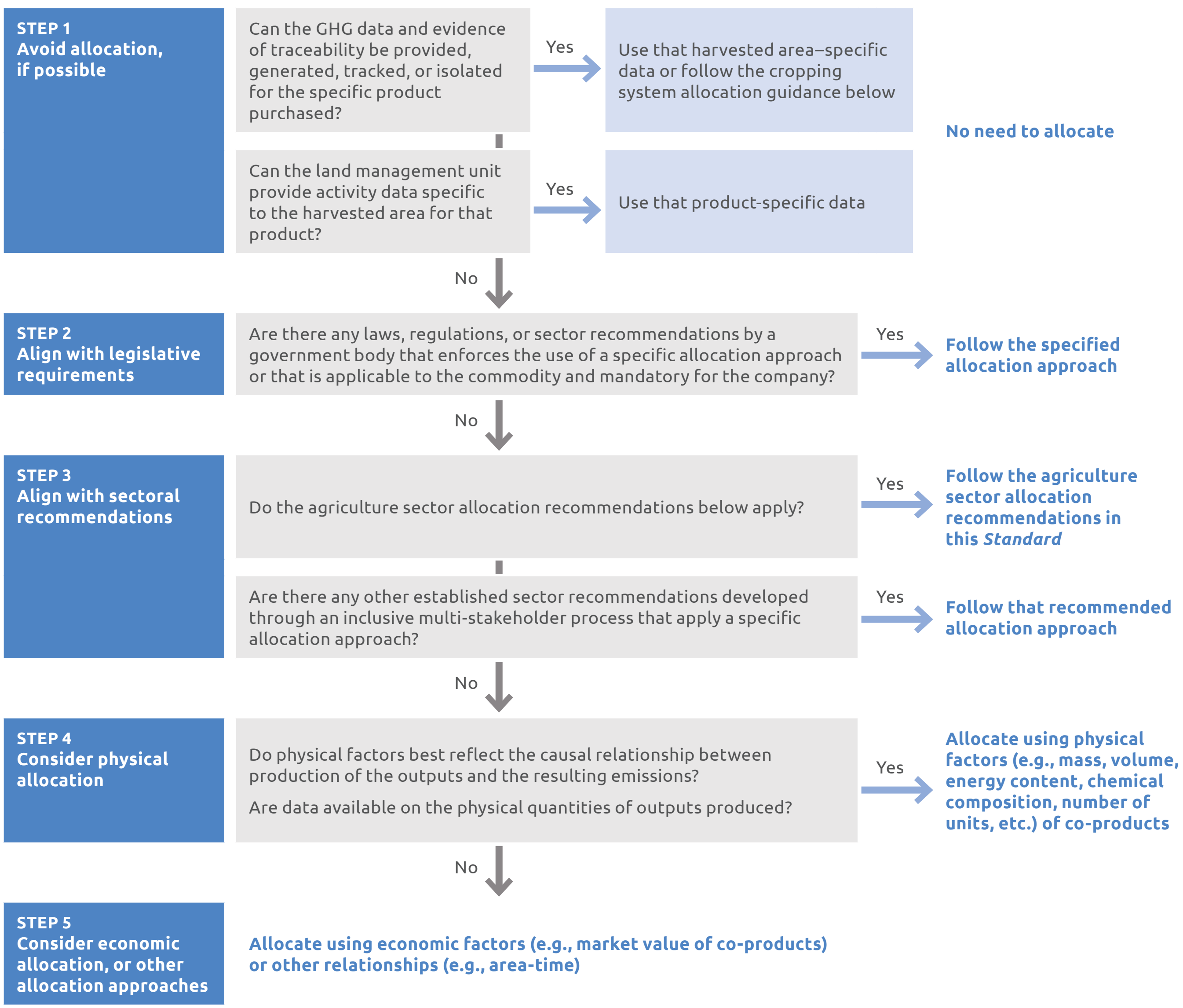
- best supports effective decision-making for GHG reduction activities
- otherwise adheres to the principles of relevance, accuracy, completeness, consistency, and transparency

Chapter 8 in the Scope 3 Standard (2011) provides guidance on how to apply these principles generally to different sectors. Guidance for applying these principles to the agriculture sector is provided below (see "Agriculture sector allocation recommendations").

Companies **should** ensure that the same allocation methods are used for each process to avoid the over-counting or under-counting of total emissions from the system, in accordance with the *Scope 3 Standard.* Companies must ensure that allocated removals do not exceed total removals in the system, following Requirement 22 in Chapter 12.

Companies **should** use the decision tree in Figure 6.1 as guidance on how to best adhere to the recommendations above.

Figure 6.1 Allocation method decision tree for companies, as applied to the LSR Standard



Agriculture sector allocation recommendations

For the agriculture sector, companies **should** choose an allocation approach according to the following tiers in the value chain where the partitioning of GHG emissions, removals, or other land-related metrics among materials or products is occurring:

- **Allocation at the land**: Where different agricultural products are generated on the same LMU and benefit from the same inputs (e.g., cropping systems such as intercropping, double- or multi-cropping systems), physical allocation is not recommended. Companies **should** first follow the guidance below for the specific cropping system (if applicable), and then follow the hierarchy of land allocation approaches among agricultural products:
  - **Allocation approaches for specific cropping systems**
    - **Crop rotations**: Calculate carbon stock changes and other GHG emissions over the full crop rotation and allocate across all crops in the rotation.
    - **Crop rotations with cover crops**: Allocate net land carbon stock changes and other GHG emissions associated with cover crop production (or other non-cash crops, including temporary fallow land) across all cash crops in the crop rotation or to the subsequent cash crop if not part of a crop rotation with multiple cash crops. This allocation approach may also apply to agroforestry systems which include plants or trees that are not associated with the harvested product.
    - **Intercropping systems**: Follow the hierarchy below of land allocation methods among agricultural products of the intercropping system.
  - **Hierarchy of land allocation methods among agricultural products**
    1. **Consider economic allocation**: Allocate emissions, removals, and other metrics based on the share of the total economic value for all products from the agricultural production system in the reporting year or over the crop rotation.
    2. **Consider area–time allocation**: Allocate emissions, removals, and other metrics based on the square meter-year (m^2yr) for all products from the agricultural production system in the reporting year or over the crop rotation.
- **Allocation at the agricultural product processing facility**: If multiple co-products are generated from the same agricultural product at a processing facility, companies **should** allocate based on the share of the total economic value for each co-product. Some examples include:[2]

Primary co-product	Secondary co-product
Cereal or flour	Bran, germs, and hulls of seeds
Oil	Cake
Sugar	Pulp and molasses
Starch	Pulp, gluten, and germs
Fruit or vegetable	Pomace and stones
Cotton fiber	Hulls of seeds

Allocation approaches for waste and recycled material

Companies **should** apply the following allocation approaches for waste and recycled material:

- **Waste**: Waste is an output of a system that has no market value. If a system or process produces waste during production, no emissions, removals, or other metrics from the system or process **should** be allocated to the waste. The company sourcing waste **should not** account for any upstream indirect emissions, removals, or other metrics associated with waste within their scope 3, prior to the generation of the waste. All emissions, removals, and other metrics from the system **should** instead be allocated among the system's other outputs. Note that this allocation guidance for waste is distinct from how companies must account for emissions and other metrics associated with losses and waste of agricultural products (e.g., food loss and waste) that occurred prior to purchase by the reporting company, in scope 3, category 1; see Requirement 3.
- **Recycling**: Recycling occurs when a product or material exits the life cycle of one product to be reused or recycled as a material input in another product's life cycle. Companies **should** follow the *Scope 3 Standard* system boundaries for recycling, based on the recycled content allocation method. The life cycle of acquired recycled material(s) is assumed to start with the recycling process. Therefore, the use of recycled material **should** not be associated with any impacts upstream of the recycling process. All subsequent emissions in the life cycle (beginning with the recycling process) are accounted for.
    - Companies may use the recycled content allocation method for post-consumer waste that is recycled (e.g., used cooking oil, recovered fiber) or reused (e.g., material/residue that is reused as a material input in another process) regardless of the market value of the waste.

6.4 Guidance on the requirements and recommendations

Section 6.4 provides general guidance for how companies should approach evaluating and selecting data and calculation approaches when compiling their inventory. This general guidance applies to all accounting categories in this Standard. General guidance on selecting data is discussed in Section 6.4.2, and guidance on selecting calculation approaches is discussed in Section 6.4.3. In Chapters 7–15, specific guidance on data and methods used to account for each corresponding accounting subcategory is presented in Sections [7–15].5.2 and [7–15].5.3, respectively. Companies may find it useful to simultaneously consult these corresponding sections in Chapters 7–15 alongside the general guidance provided here in Chapter 6 (Table 6.1).

In many cases, data selection depends on a given calculation approach, and vice versa. Although data and methods can be considered separately, the evaluation and selection of data and methods will occur simultaneously in most cases (Figure 6.2). Many of the same general considerations that a company should consider when prioritizing data collection efforts also pertain to the selection of calculation approaches (Tables 6.2 and 6.7). A decision tree to guide companies in selecting data and calculation approaches for each accounting subcategory (Chapters 7–15) is presented in Sections [7–15].5.1 in each chapter.

Data selection is also influenced by the level of traceability and corresponding scope 3 spatial boundary the reporting company can currently establish, the level of traceability and scope 3 spatial boundary that the company seeks to achieve, and the possible calculation approaches that can be used to complete the accounting, given a particular spatial boundary of analysis. Guidance on traceability and setting spatial boundaries is the subject of Chapter 5 in this *Standard* and *Guidance*.

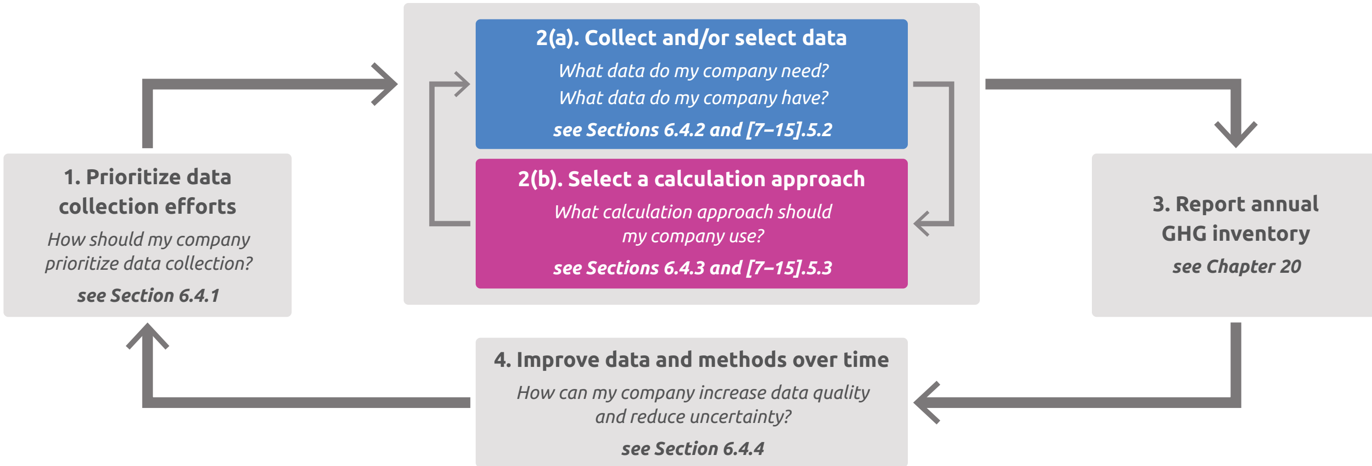
Table 6.1 How companies can use Chapter 6 with category-specific guidance in Chapters 7–15

Chapter 6 section	Corresponding section in *Guidance* Chapters 7–15	Description of guidance in the corresponding section
6.4.1 Prioritizing data collection efforts	**Chapter [7–15].5.1**	Presents a high-level decision tree to assist companies in selecting or calculating an appropriate emission factor, carbon stock change factor, or other metrics relevant to a given accounting subcategory, according to a company's level of traceability and corresponding spatial boundary
6.4.2 Selecting data	**Chapter [7–15].5.2**	Provides a summary of the data needed to implement certain calculation approaches for a given accounting subcategory
6.4.3 Selecting a calculation approach	**Chapter [7–15].5.3 (and higher-numbered subsections)**	Provides relevant equations and calculation guidance needed to implement calculation approaches for a given accounting subcategory

This *Standard* recommends companies to improve data collection over time to increase the accuracy of the information in their inventory, as relevant to meeting their specific business goals. In general, improvement over time follows an iterative process (Figure 6.2) that includes evaluating data quality, gathering more primary data specific to a company's operations and value chain activities over time, and prioritizing data and methods that can reduce uncertainty. Section 6.4.4 provides guidance on how companies can approach improving data and reducing uncertainty over time.

Lastly, Section 6.4.5 also provides general guidance on allocation methods for scope 3 emissions, removals, land occupation, and other metrics. Allocation is the process of partitioning impacts (emissions, etc.) from a single facility, process, or other system among its various outputs, and is commonly needed when compiling the scope 3 inventory.

Figure 6.2 Selecting and improving data and methods to compile the inventory



6.4.1 Prioritize data collection efforts

A company's data collection efforts will vary based on several considerations, summarized in Table 6.2.

Table 6.2 Considerations for prioritizing data collection efforts to compile the GHG inventory

Consideration	Description	Relevant chapter in *Standard* and/or *Guidance*
Company sector and position in the value chain	The relevant data needed to compile the inventory will depend on the particular sector and tier in the value chain a company is situated in (e.g., this situation defines the upstream suppliers and downstream customers that can provide data).	Not covered; sector-specific guidance can address these challenges.
Scope 3 categories relevant to the company's activities	Companies will have diverse upstream and downstream scope 3 impacts reported across the 15 scope 3 categories (see Tables A.1 and A.2 in the Annex for scope 3 category descriptions). Data and methods will vary by scope 3 category, and several scope 3 categories require the quantification of life cycle impacts.	**Chapter 4**
Level of traceability and spatial boundary	The level of traceability a company can establish, and the corresponding scope 3 spatial boundary that is set, influences what data a company needs to complete the scope 3 accounting for the emissions, removals, and other metrics attributable to a company's value chain activities.	**Chapter 5**
Type or quality of data needed to calculate and report emissions, removals, and other metrics	The type of data needed to calculate emissions, removals, land use, land carbon leakage, and other metrics depends on the calculation approach. In general, this *Standard* offers flexibility in the data used to calculate GHG emissions, land use, and land carbon leakage. To account for and report removals, less flexibility is permitted: a company must apply empirical data specific to sinks and pools where carbon is stored (see Requirement 21).	***Guidance* sections:** **[7–15].5.2, in Chapters 7–15**
Type or quality of data needed to enable business goals supported by the GHG inventory	Preparing a GHG inventory for land sector activities and removals can support several business goals. For example, a company may be interested in tracking progress toward targets based on specific actions and interventions in the company's operations and supply chain. Certain data may be needed to quantify and report such progress to internal or external stakeholders.	**Chapter 2**

The “Higher accuracy data and methods” recommendation in Section 6.3 recommends that companies prioritize the collection of primary data for the GHG sources and sinks that are most significant (i.e., that comprise the greatest share of a company’s inventory) across their operations and value chain and/or where the opportunity for emission reduction and removals enhancements is greatest. Section 7.1 in the *Scope 3 Standard* describes general approaches for prioritizing the collection of primary data in line with a company’s broader business goals, including:

- **Prioritizing by emissions**: Companies may decide to determine which products are the most emissions-intensive within their inventory using secondary data from LCA databases and then prioritize primary data collection for the products with the greatest emissions. For example, an ice cream company might produce equal amounts of ice cream and sorbet, but since dairy products are relatively GHG-intensive, the company may prioritize collecting primary data for the milk they source rather than the fruit in the sorbet. Under this approach, the majority of the company’s emissions would be accounted for using relatively high-quality data specific to its dairy suppliers.
- **Prioritizing by volume or spend**: If a company sources many different products and it is difficult to distinguish the relative emissions intensity of one product versus others, the company may choose to prioritize primary data collection for the products or suppliers with the greatest share of their total volume sourced, volume sold, or spend (i.e., expenditure), by product type or supplier. This prioritization scheme assumes that, while the product or supplier in question might not have the highest emissions per unit, the total emissions attributed to that product type or supplier make up a significant percentage of the reporting company’s total emissions, and the reporting company may have relatively more influence over value chain partners and production decisions. For example, a breakfast cereal company might purchase a wide range of products such as various grains, nuts, milk powder, and sugar, but wheat is the product that the company purchases the greatest quantity of. While the emissions per unit of wheat are likely not larger than other ingredients (e.g., milk powder), the total volume of wheat purchased is much larger, and thus the total emissions attributed to their wheat purchases are larger than other, more minor ingredients.
- **Other criteria**: Many other factors can influence how a company prioritizes collecting primary data and improving data quality. For example, companies might also choose to prioritize primary data collection for scope 3 activities that they have more influence over to support reducing emissions per unit, or to improve data reliability and other quality indicators over time.

Preparing a data management plan can serve as an important first step when selecting data and prioritizing data collection efforts. A data management plan can be used to document the data collection process required to prepare a complete GHG inventory, including the data types, data sources, assumptions, collection protocols, and data quality information for each relevant activity and source category. For more information, refer to the *Scope 3 Standard*, Annex C (Data Management Plan).

6.4.2 Selecting data

This section provides general guidance for selecting data when compiling the inventory. Section 6.4.2.1 provides an overview of types of data that are referenced in this *Standard*, and Section 6.4.2.2 provides general guidance for selecting data. Companies should refer to sections [7–15].5.2 within Chapters 7–15 in this *Guidance* for specific guidance for selecting data needed to complete the accounting for each individual accounting subcategory.

6.4.2.1 Data types

This section describes key types of data and other information used to compile the inventory.

PRIMARY AND SECONDARY DATA

Data can be classified as primary data or secondary data:

- **Primary data**: Data obtained from specific activities within a company's operations or value chain (e.g., site-specific data). Primary data can be based on direct measurements, models, or other methods and is not necessarily generated by the reporting company.
- **Secondary data**: Data that is not from specific activities within a company's operations or value chain (e.g., proxy or regional average data).

For example, if a company sources dairy products, primary data can include data characterizing the age classes, feed baskets, and live weights of a herd, or soil carbon measurements from pastures on a specific dairy where a dairy product purchased by the reporting company is produced. These data don't necessarily need to be generated by the reporting company. Similarly, as per the definition above, such primary data are not necessarily empirical (i.e., based on direct measurements or observations); note that this primary data definition may differ in this regard from definitions used in other applications or contexts. In contrast, secondary data might include average data representative of lands and activities in the relevant spatial boundary (e.g., another dairy or set of dairies in the same region used as a proxy).

Table 6.3 outlines the advantages and disadvantages of collecting and applying primary and secondary data when compiling the inventory. In general, primary data provides a more accurate representation of the impacts of a company's operations and value-chain activities and enables a company's actions to be accurately reflected in the inventory (e.g., farm-level interventions that would not be captured in secondary data). Process-specific or product-specific primary data can also better reflect relevant geographic and temporal boundaries compared to average or proxy data collected from an external source. However, primary data can be more time- and resource-intensive to collect. In contrast, secondary data are more widely available but are less representative of a company's activities. Because secondary data are not directly linked to a company's activities, secondary data in general less accurately reflect changes in management that reduce emissions or increase removals.

Table 6.3 Advantages and disadvantages of collecting and using primary versus secondary data to compile the inventory

Type of data	Advantages	Disadvantages
Primary data (e.g., supplier-specific data)	• Provides better representation of a reporting company's specific value chain activities • Enables performance tracking and benchmarking of individual value chain partners by allowing companies to track operational changes from actions taken to reduce emissions at individual facilities/companies and to distinguish between suppliers in the same sector based on GHG performance • Expands awareness, transparency, and management of GHGs throughout the supply chain to the companies that have direct control over emissions • Allows companies to better track progress toward GHG reduction targets	• May be costly • May be difficult to determine or verify the source of quality of data supplied by value chain partners
Secondary data (e.g., industry-average data)	• Allows companies to calculate emissions when primary data is unavailable or of insufficient quality • Allows companies to more readily understand the relative magnitude of impact of various scope 3 activities, to identify GHG hot spots, and to prioritize efforts in primary data collection, supplier engagement, and GHG reduction efforts • Can be more cost-effective and easier to collect • Can be useful for accounting for emissions from minor activities	• Data may not be representative of the company's specific activities • Does not reflect operational changes undertaken by value chain partners to reduce emissions • Could be difficult to quantify GHG reductions from actions taken by specific facilities or value chain partners • May limit the ability to track progress toward GHG reduction targets

Source: GHG Protocol Scope 3 Standard (WRI and WBCSD 2011a).

OTHER TYPES OF DATA AND INFORMATION FREQUENTLY REFERENCED IN THIS *GUIDANCE*

In this *Standard* and *Guidance*, the following common data types are also frequently referenced:

- **Activity data**: A quantitative measure of a level of activity related to a source or sink that results in GHG emissions, removals, and/or other impacts quantified by other accounting categories. Examples of activity data include the quantity of a fertilizer or other soil amendment applied to a field, the number of livestock in an operation, the volume of manure stored in a facility, or the frequency of tilling. Activity data can be primary or secondary (e.g., the specific quantity of fertilizer applied to a field or a regional average application factor).
- **Emission factor, removal factor, carbon stock change factor, and other factors**: A factor is a value that estimates the quantity of emissions, removals, or other metric per unit of activity (e.g., per tonne of fuel consumed, per tonne of product produced, etc.). Factors relevant to the reporting company can be provided by a third party (e.g., emission factors from an LCA database or a specific supplier) or can be calculated directly by the reporting company. Emission and other factors can be based on primary or secondary data, while removal factors are required to be based on primary data (see Requirement 20). Absolute GHG emissions (removals, etc.) can be estimated by multiplying activity data by an emission factor.
- **Strata**: Strata are a set of uniquely defined categories, defined relative to a single or multiple variables, where each category is defined by a characteristic(s) that is distinct from other categories in the set. Complete and accurate calculation of absolute emissions and other metrics may benefit from stratifying activity data, emission and carbon stock change factors, and other types of information across different strata (e.g., land areas with distinct climate, ecological, edaphic, or management characteristics, or age and sex classes of livestock). For example, the same type or level of an activity applied on lands with different soil types or

average annual precipitation may produce different quantities of emissions or other impacts. Companies that use measurement-based calculation approaches may follow sampling protocols that prescribe the distribution, quantity, frequency, and so on, of measurements taken across strata.

- **Product-level data**: Product-level data are cradle-to-gate GHG emissions, removals, or other metrics for a specific product of interest, typically provided by a supplier of the relevant good(s) or service(s). Such data may be generated following product LCA methods, which overlap with, but may differ from, scope 3 accounting methods, as described in Box 6.1.

Box 6.1 Relationship between product-level life cycle assessment and scope 3 accounting

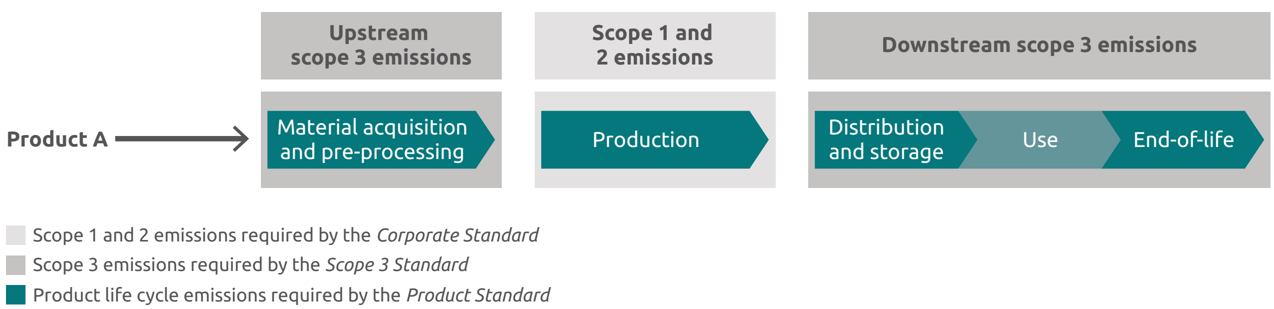
The GHG Protocol's *Scope 3 Standard* and *Product Standard* both take a value chain or life cycle approach to GHG accounting and were developed simultaneously. The *Scope 3 Standard* and the *Land Sector and Removals Standard* and *Guidance* build on the GHG Protocol's *Corporate Standard* and account for value chain emissions at the entity level, while the *Product Standard* accounts for life cycle emissions at the individual product level. Figure B6.1-1 below illustrates how the scope of emissions at the entity level corresponds to life cycle stages at the product level. See Section 1.5 for further discussion of how this *Standard* and *Guidance* relate to other GHG Protocol standards.

Common data are used to develop entity-level scope 3 inventories and product-level inventories that include the land sector, including data collected from suppliers and other companies in the value chain. Since there can be overlaps in data collection, companies may find added business value and efficiencies in developing scope 3 and product-level inventories in parallel. Integrated use might include:

- Applying the *Corporate Standard, Scope 3 Standard*, and this *Standard* (to determine the company's total scope 1, scope 2, and scope 3 emissions, removals, and other metrics), using the results to identify land products with the most significant emissions and other metrics, then using the *Product Standard* to identify mitigation opportunities in the selected products' life cycles.
- Using product-level GHG data based on the *Product Standard* as a source of data to calculate scope 3 land emissions, removals, or other metrics associated with selected product types.

Note that there are some areas where product-level LCA accounting may differ from or provide additional detail to entity-level scope 3 accounting, such as defining the unit of analysis; establishing the assessment boundary; collecting data; assessing data quality; allocating emissions, removals, or other metrics, etc. Companies should consider whether product-level LCA data must be adapted to align with scope 3 accounting requirements. Following Requirement 3 in this *Standard*, land sector requirements in this *Standard* take precedence over previous land-sector requirements, recommendations, and guidance in the *Product LCA Standard* when preparing product-level inventories.

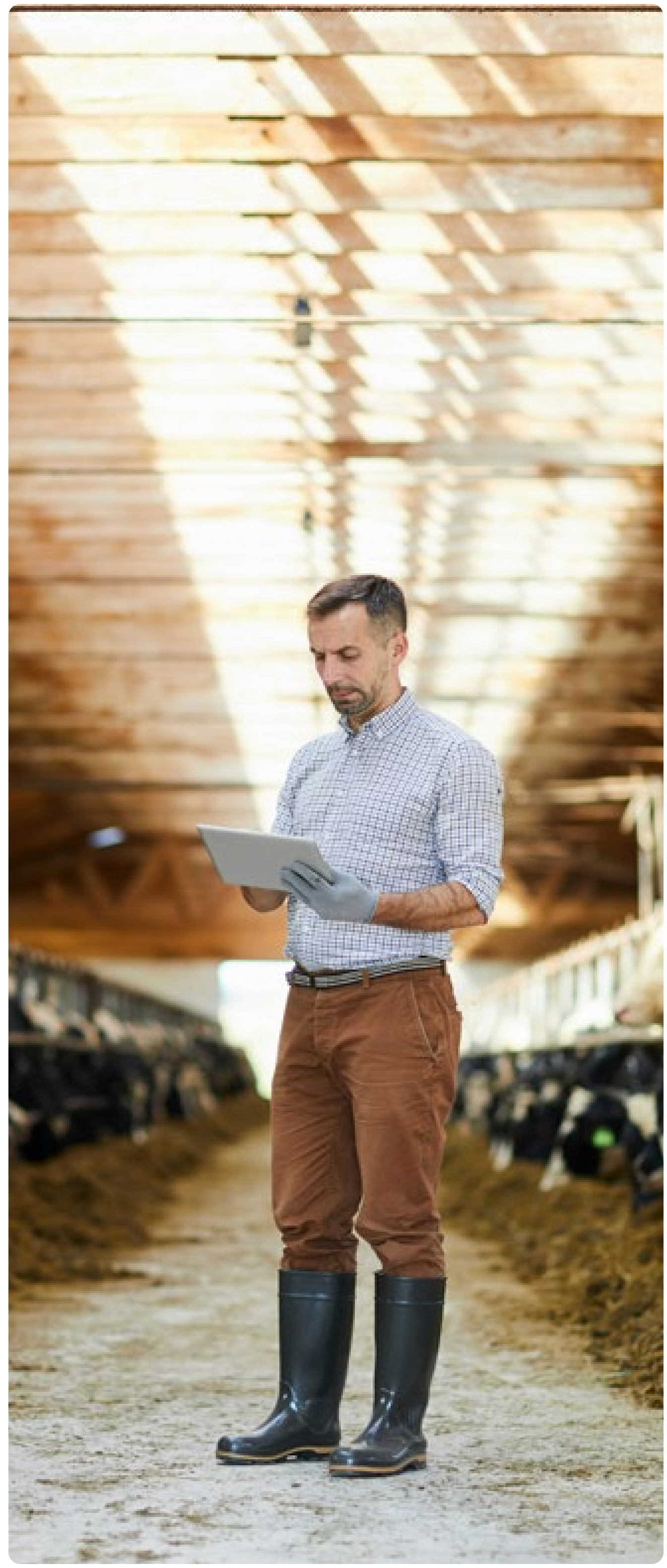
Figure B6.1-1 Relationship between the Corporate Standard, Scope 3 Standard, and Product Standard for a company manufacturing product A



Source: GHG Protocol Scope 3 Standard (WRI and WBCSD 2011a).

6.4.2.2 General guidance for selecting data

Selecting data for calculation purposes depends on many of the same considerations presented in Table 6.2. As depicted in Figure 6.2, evaluation and selection of data and calculation approaches are interdependent and inform one another (i.e., the type of data available or needed depends on the type of calculation approach implemented, and vice versa); however, one or the other might be limiting. In general, this *Guidance* offers flexibility in the data used to estimate GHG emissions, land use, and land carbon leakage, while requiring that higher-quality primary data be used to calculate removals. Table 6.4 provides a general summary of the quality of data and methods needed to account for and report certain accounting categories.



When compiling the scope 3 inventory, data selection largely depends on the level of traceability and corresponding scope 3 spatial boundary a company can currently establish, the level of traceability and scope 3 spatial boundary that a company seeks to establish, and the calculation approaches that can be used to complete the accounting at a given spatial boundary. The following questions should be considered when selecting data:

- What type of data does my company need to gather and apply to satisfy the requirements and recommendations in this *Standard* (Table 6.4)?
- What type of input data are needed to implement a certain calculation approach or method (Table 6.6)?
- What type or quality of output data can a certain calculation approach provide, and how can those outputs be used?
- What type or quality of data does my company need to enable and track progress for actions and interventions in my company's operations and supply chain?
- What type or quality of data should my company prioritize (Section 6.4.1)? What are the tradeoffs between resources spent on certain data collection efforts and the likely improvements (e.g., accuracy of information in the GHG inventory, enabling of mitigation actions, etc.) to be gained from those efforts?

Table 6.4 Overview of data, methods, and uncertainty requirements across accounting categories

<table>
<tr><th>Accounting category</th><th>Required or optional?</th><th>Data</th><th>Methods</th><th>Uncertainty</th></tr>
<tr><td>Emissions
(see Chapters 7, 9, 10)</td><td>Required (Companies are required to account for and report all emissions)</td><td>Companies should use the most accurate, complete, and representative data available</td><td>Land use change emissions: Require the most accurate calculation approach that a company's data availability and value chain traceability allow
All other land emissions: Companies should use the most accurate methods possible</td><td>Companies should assess and report uncertainty either qualitatively or quantitatively</td></tr>
<tr><td>Removals
(see Chapter 12)</td><td>Optional (Companies may account for and report removals, if the removal requirements in Chapter 12 are met)</td><td>Requires primary data, i.e., empirical data (not necessarily generated by the company) specific to the sinks and pools where carbon is stored is needed to estimate annual net carbon stock changes</td><td>Companies should use the most accurate methods possible</td><td>Requires quantification and reporting of uncertainty estimates, including the uncertainty range based on a specified confidence level, the removals value, and justification for how the removal value is conservative</td></tr>
<tr><td>Land use
(see Chapter 8)</td><td>Required</td><td rowspan="2">Companies should use the most accurate, complete, and representative data available</td><td rowspan="3">Companies should use the most accurate methods possible</td><td rowspan="3">Companies should assess and report uncertainty either qualitatively or quantitatively</td></tr>
<tr><td>Land carbon leakage
(see Chapter 8)</td><td>Required</td></tr>
<tr><td>Biogenic product and TCDR-based product CO_2 emissions
(see Chapter 11)</td><td>Required</td><td>To separately report, companies should use data that are representative of lands where the biogenic product was sourced from (at a minimum, country of origin), or the origin of the CO_2 or carbon in TCDR-based products</td></tr>
</table>

When calculating emissions, this *Standard* does not require that all data and other types of information used to calculate average emissions within the scope 3 spatial boundary be primary data. Instead, a company should use the most accurate, complete, and representative data available. In many cases, this will mean applying a combination of primary and secondary data to calculate emissions across different emission accounting categories (e.g., primary activity data and secondary data for an emission factor, or primary data for some product types and secondary data for others).

For example, for a company with LMU-level traceability for the beef they purchase, calculating scope 3 emissions from enteric fermentation could involve either using a supplier-specific emission factor from the individual rancher(s) (i.e., based on primary data), or a combination of primary and secondary data types, such as supplier-specific primary activity data (e.g., the number of cattle on the livestock farm) multiplied by an emission factor selected from IPCC guidance or a national GHG inventory that represents the average quantity of methane emitted per cow in a certain region, country, or other area (i.e., secondary data).

6.4.3 Selecting a calculation approach

This section provides general guidance for selecting a calculation approach to complete the accounting. Section 6.4.3.1 provides an overview of types of calculation approaches, and Section 6.4.3.2 provides general guidance for selecting a calculation approach. Companies should refer to sections [7–15].5.3 within Chapters 7–15 in this *Guidance* for specific calculation guidance for each accounting category.

6.4.3.1 Types of calculation approaches

There are two general calculation approaches to estimate emissions, removals, and other metrics: calculation and direct measurement (Table 6.5).

- **Calculation**: The quantification of GHG emissions, removals, and/or other metrics using factor-based, model-based, or remote sensing-based approaches.
  - **Factor-based calculation approach**: Methods that multiply activity data relevant to the company by an emissions factor, removal factor, or other factor (e.g., land occupation factor, carbon opportunity cost factor, etc.) to determine emissions, removals, or other metrics for a given process. A factor-based calculation approach can utilize:
    - factors relevant to the reporting company provided by a third-party (e.g., life cycle emission factors from an LCA database or supplier-specific emissions factors); or
    - factors calculated by the reporting company based on primary and/or secondary data (e.g., removals factors calculated based on soil carbon and management practice data provided by a farm the company has traceability to).
  - **Model-based calculation approach**: Methods that use mathematical or computational modeling techniques to estimate emissions, removals, or carbon stock changes, or related metrics from input variables and fixed model parameters calibrated to the specific model applications.
  - **Remote sensing-based calculation approach**: Methods that use satellite or aerial information to collect activity data to estimate emissions, removals, or other metrics. Some remote sensing approaches can detect carbon stock changes, which may produce estimates that are comparable to those from direct measurement approaches if the remote-sensing method is properly calibrated to ground-based inventory data.
- **Direct measurement**: The quantification of GHG emissions or removals, or associated carbon stock changes, using direct monitoring or measurement of GHG fluxes. Measurement-based inventories or sampling approaches involve developing a sampling protocol, selecting representative sampling sites, collecting initial samples, re-sampling according to the sampling protocol, analyzing data for estimated values and uncertainty, and reporting the results, sampling, and quality control procedures. Direct measurement will generally be sample-based and require extrapolation for full coverage.

In practice, GHG accounting often involves **hybrid calculation approaches** that combine direct measurement and calculations. For example, direct measurements of carbon stock changes can be combined with calculation approaches to calibrate model-based or remote sensing-based methods or to develop new emission factors or carbon stock change factors for factor-based calculation approaches.

Table 6.5 provides general examples of primary and secondary data that can be used to calculate GHG emissions, removals, and/or carbon stock changes when implementing different calculation approaches. Specific guidance for selecting data when accounting for individual accounting categories using certain calculation approaches is provided in sections [7–15].5.2 in Chapters 7–15.

Table 6.5 Description of general calculation approaches

Calculation approach		Description	Examples
Calculation	**Factor-based calculation approach**	Methods that multiply activity data by an emission factor or carbon stock change factor to determine emissions, removals, or other accounting category values for a given process	• LCA database-derived life cycle emissions factors • Emission factors from a supplier's product-level LCAs
	Model-based calculation approach	Methods that use mathematical or computational modelling techniques to estimate emissions, removals, or carbon stock changes using input variables and fixed parameters calibrated to the specific model applications	• Farm-level GHG calculation tools and models
	Remote sensing-based calculation approach	Methods that use satellite or aerial information to collect activity data to estimate emissionss, removals, or carbon stock changes	• Satellite-based deforestation monitoring • LiDAR
Direct measurement	**Measurement-based calculation approach**	Methods that directly quantify GHG emissions, removals, or associated carbon stock changes, using monitoring or measurement of GHG fluxes	• Direct on-farm measurement of carbon stock changes (e.g., soil carbon) based on repeated measurement of carbon stocks within pre-defined strata using a pre-defined sampling scheme • Ground-based inventory sampling to calibrate types of remote sensing techniques
Hybrid calculation approaches		A combination of methods that involve both calculation and direct measurement approaches	• Direct on-farm measurements of vegetation carbon combined with a soil carbon model

Methods, whether representing a direct measurement or a calculation approach, can entail different levels of methodological complexity, data requirements, and calibration. In general, more sophisticated methods can produce more accurate results. The IPCC *Guidelines for National GHG Inventories* define methodological "tiers" which categorize calculation approaches by their relative level of methodological complexity, data requirements, and accuracy. Tier 1 methods are the most simplified methods using global or regional estimates with large uncertainty ranges. Tier 2 methods have intermediate complexity and involve country- or management-specific data with lower uncertainty ranges. Tier 3 methods require the most intensive data collection and analysis but can lead to more accurate estimates, with reduced uncertainty ranges. Note that the IPCC's Tier 1–3 terminology can also be used to describe data that are the outputs of certain methodologies (e.g., a "Tier 2" emission factor).

Table 6.6 Examples of data types by calculation approach

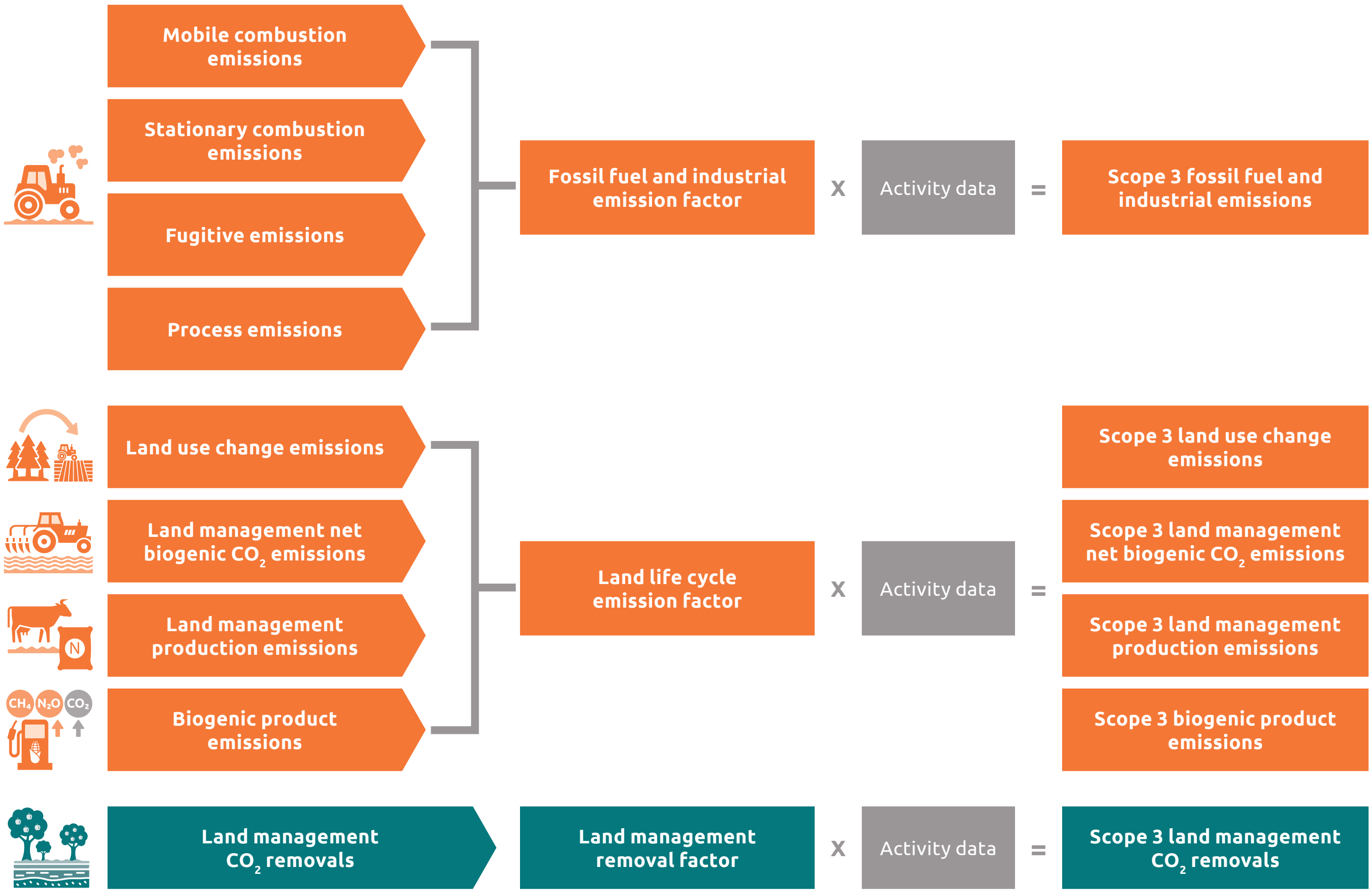
Calculation approaches	Data type	Example activity data	Example emission (and other types of) factors and/or data
Factor-based calculation approach	Primary data	Product quantity or land area by known sourcing areas	Primary emission factors or data based on direct measurements taken by suppliers
	Secondary data	Product quantity by unknown sourcing areas or country of origin	IPCC Tier 1 defaults or Tier 2 country-specific factors
Model-based calculation approach	Primary data	Supplier-specific input data from known sourcing areas	Calibration using direct measurements within the sourcing region
	Secondary data	Input data based on average practices within the country	Calibration using regional or global average measurements
Remote sensing-based calculation approach	Primary data	Remote sensing data of land cover in known sourcing areas	Remote sensing-based estimates of carbon stock changes calibrated with ground-based data
	Secondary data	Remote sensing data of land use change from known countries of origin	Carbon stock estimates from Tier 1 or Tier 2 data
Measurement-based calculation approach	Primary data	Land use and stratification on known sourcing areas	Direct measurements of emissions or carbon stocks in known sourcing areas
	Secondary data	Not applicable (direct measurements are always primary data)	

SCOPE 3 CALCULATION METHODS

To quantify all relevant life cycle impacts in their scope 3 inventory, companies may need to use a combination of calculation approaches or hybrid approaches. For example, a company calculating a life cycle GHG emission factor for soy used in their products may use factor-based approaches to estimate upstream GHG emissions from fertilizer application during production, mobile combustion during transportation, and stationary combustion during food processing; remote sensing-based approaches to estimate land use change emissions; and model-based approaches to estimate carbon stock changes from land management practices. When selecting life cycle emission factors, companies must ensure all relevant accounting categories are included and document the quantification methods and data associated with the estimates, following the reporting requirements in Section 6.2.2.

Companies are required to separately account for and report emissions and removals by accounting subcategory (see Requirement 32). Companies cannot use net emission factors that combine emissions and removals for scope 3 accounting and reporting purposes. For scope 3 accounting, this requires companies to separately calculate and/or compile emission factors and removals factors by accounting subcategories when collecting and sharing factor data with supply chain partners (see Figure 6.3). For example, a retailer using secondary life cycle emission factor data would need to identify life cycle emissions factors that can distinguish the land use change emissions, land management production emissions, and land management net biogenic CO_2 emissions for the products they purchase. Similarly, a food processing facility with traceability to the farms it sources crops from would need to request separate data on each “land emissions” subcategory and data on removals associated with the crops it purchases.

Figure 6.3 Calculating separate scope 3 life cycle GHG emission and removals factors



6.4.3.2 General guidance for selecting a calculation approach

The choice of a calculation approach will depend on many of the same considerations as presented in Table 6.2. As depicted in Figure 6.2, the evaluation and selection of data and calculation approaches are interdependent and should occur simultaneously. Companies should refer to Sections [7–15].5.3 in Chapters 7–15 for specific calculation guidance for individual accounting categories.

The following questions should be considered when selecting a calculation approach:

- What type of input data is needed to implement a certain calculation approach (see Table 6.6)?
- What type or quality of output data can a certain calculation approach or method provide, and how can those outputs be used?
- What type of calculation approaches or methods does my company need to apply to satisfy the requirements and recommendations in this *Standard*?
- What are the tradeoffs between resources spent on implementing certain calculation approaches and the likely improvements (e.g., accuracy of information in the GHG inventory, enabling mitigation actions, etc.) to be gained from those efforts?

When evaluating and selecting a calculation approach to complete the accounting for different aspects of the inventory, companies should evaluate tradeoffs (Table 6.7) amongst the following considerations:

- Accuracy, continuity, and uncertainty associated with the calculation approach
- Relevance of calculation approaches and methods to a company's operations and value chain
- Technical expertise and capacity required to implement the calculation approach
- Available tools and resources to support implementation
- Secondary data available for activities relevant to the company's operations or value chain
- Primary data needed to implement the calculation approach
- Consistency across datasets that will be directly compared across time

Table 6.7 Advantages and disadvantages of calculation approaches

Calculation approaches		Advantages	Disadvantages
Calculation	**Factor-based calculation approach**	• Simplest calculation approach to apply	• Often unable to represent specific land management practice changes • Estimates contain relatively large uncertainty
	Model-based calculation approach	• Able to represent a range of land management practices, depending on model design and calibration • May cover estimates of multiple GHGs, metrics, etc.	• Requires technical expertise to implement correctly • Requires direct measurements to calibrate to site-specific or management-specific conditions
	Remote sensing-based calculation approach	• Able to represent a range of land management practices, depending on model design and calibration • Provides spatially explicit estimates that are more geographically representative and have full spatial coverage • Can improve the accuracy of management activities • Reduces the cost involved in data collection • Can reflect changes over time	• Requires detailed technical expertise to implement • Requires direct measurements to calibrate to site-specific or management-specific conditions
Direct measurement	**Measurement-based calculation approach**	• Able to represent specific land management practices, depending on sampling design and stratification • Provides the most accurate estimates	• Costly and resource-intensive (e.g., in terms of time, labor, etc.) • Requires site visits

There is an increasing number of public and proprietary tools (e.g., calculation spreadsheet tools, software, and protocols) available to estimate land emissions, removals, and other metrics that combine elements of factor-based, remote sensing-based, and model-based calculation approaches. Off-the-shelf tools designed to be accessible to relatively non-technical users tend to implement Tier 1 or Tier 2 approaches. In general, this *Guidance* does not recommend specific tools for compiling the inventory. A company should evaluate and select tools using the same general guidance that is presented in this chapter for selecting data and calculation approaches, improving data quality, and reducing uncertainty over time. Tools must also conform to the accounting and reporting principles and relevant requirements in this *Standard*.

When evaluating and selecting a calculation tool, the following questions should be considered:

- Is the tool comprehensive in terms of its coverage of different emission sources, GHGs, and management activities, particularly those activities that are implemented or planned in the relevant spatial boundary? Does the tool integrate the effects of multiple management activities across lands in the relevant spatial boundary (e.g., land management unit or sourcing region)?
- Is the tool geographically representative? Is the tool calibrated to the region/area of interest?
- What input data are required, and will land managers or value chain partners be able to provide those data?
- Does the tool have access to or align well with representative external data (e.g., weather data or soil databases)?
- Is the tool transparent about its methodology, including limitations, uncertainty, and assumptions?
- Does the tool provide estimates of uncertainty?
- Is the tool sufficiently accurate to achieve business objectives for compiling a GHG inventory? Does the tool provide additional functionality to support business objectives beyond GHG inventory accounting?
- Is the tool up to date? How frequently is the tool updated (e.g., are relevant factors and parameters updated on an annual basis)?
- Does the tool have verification functions (e.g., are ranges enforced for the values of activity data)?
- How much labor and technical expertise is required to use the tool?
- Does the tool have a user-friendly interface that is aligned with inventory accounting categories and that is accessible to inventory compilers or auditors?
- Can the tool quantify GHG performance metrics?
- Can the tool quantify other metrics or environmental impacts beyond GHG fluxes (e.g., nitrate or phosphorus pollution)?
- Is the tool otherwise consistent with the GHG accounting and reporting principles in this *Standard*?

6.4.4 Improving data and methods over time

Companies are recommended by this *Standard* to improve data collection over time to increase the accuracy of the information in their inventory as relevant to meeting their specific business goals. In general, improvement over time includes evaluating data quality, gathering more primary data specific to their operations and value chain over time, and prioritizing data and methods that reduce uncertainty.

Companies are also recommended to improve the quality of data that are the outputs of calculations by calibrating model-based and remote sensing-based quantification methods using empirical data specific to the land areas, management practices, and GHG impacts (i.e., carbon stock changes or GHG emissions) under analysis.

Secondary data, generally of lower quality compared to primary data, can be used to address data gaps where primary data is not available. Both secondary and primary data should be evaluated against data quality indicators (Table 6.8).

6.4.4.1 Improving data quality and reducing uncertainty

Companies should evaluate data quality when selecting data and prioritizing data collection efforts over time. In general, primary data is more accurate than secondary data, but primary data can also vary in terms of quality. Data quality can be assessed against a variety of data quality indicators (Table 6.8). These indicators can influence the uncertainty associated with inventory information (see Section 6.4.4.4) and, therefore, how reliable or actionable such information is. Table 6.4 provides an overview of the uncertainty quantification and reporting requirements and recommendations across accounting categories in this *Standard*.

The main indicators to consider when selecting and improving data quality include how representative the data are of activities in a company's operations or value chain, and the completeness and reliability of the data (see Table 6.8). Table 6.9 provides an example of how each data quality indicator can be evaluated against a qualitative ranking system. Companies should select the most representative, complete, and reliable data available.

Table 6.8 Data quality indicators

Indicator	Description
Technological representativeness	The degree to which the data reflects the actual technology(ies) used
Temporal representativeness	The degree to which the dataset reflects the actual time (e.g., year) or age of the activity
Geographical representativeness	The degree to which the data sets reflects the actual geographic location of the activity (e.g., country or site)
Completeness	The degree to which the data is statistically representative of the relevant activity. Completeness includes the percentage of locations for which data is available and used out of the total number that relate to a specific activity. Completeness also addresses seasonal and other normal fluctuations in data.
Reliability	The degree to which the sources, data collection methods and verification procedures[a] use to obtain the data are dependable.

Notes: a. Verification may take place in several ways, for example by on-site checking, reviewing calculations, mass balance calculations, or cross-checks with other sources.

Source: GHG Protocol Scope 3 Standard (WRI and WBCSD 2011a), adapted from Weidema and Wesnaes (1996).

Table 6.9 Example criteria to evaluate data quality indicators

Score	Representativeness to the activity in terms of:				
	Technology	**Time**	**Geography**	**Completeness**	**Reliability**
Very good	Data generated using the same technology	Data with less than 3 years of difference	Data from the same area	Data from all relevant sites over an adequate time period to even out normal fluctuations	Verified[a] data base on measurements[b]
Good	Data generated using a similar but different technology	Data with less than 6 years of difference	Data from a similar area	Data from more than 50 percent of sites for an adequate time period to even out normal fluctuations	Verified data partly based on assumptions or non-verified data based on measurements
Fair	Data generated using a different technology	Data with less than 10 years of difference	Data from a different area	Data from less than 50 percent of sites for an adequate time period to even out normal fluctuations or more than 50 percent of sites but for a shorter time period	Non-verified data partly based on assumptions, or a qualified estimate (e.g., by a sector expert)
Poor	Data where technology is unknown	Data with more than 10 years of difference or the age of the data are unknown	Data from an area that is unknown	Data from less than 50 percent of sites for shorter time period or representativeness is unknown	Non-qualified estimate

Notes: a. Verification may take place in several ways, for example by on-site checking, reviewing calculations, mass balance calculations, or cross-checks with other sources; b. Includes calculated data (e.g., emissions calculated using activity data) when the basis for calculation is measurements (e.g., measured inputs). If the calculation is based partly on assumptions, the score should be 'Good' or 'Fair.

Source: GHG Protocol Scope 3 Standard (WRI and WBCSD 2011a), adapted from Weidema and Wesnaes (1996).

Drawing from the *Scope 3 Standard*, companies should document quality assurance and quality control (QA/QC) procedures in a data management plan. Quality control involves an internal system of routine technical activities to determine and control the quality of the inventory data and data management processes. Internal quality control is conducted by an individual within the reporting company who is independent of the team compiling the inventory. Quality assurance involves a third party (e.g., an assurance provider or scientific organization) to check and verify the estimates and assumptions underlying the inventory, either through a peer review process or an audit to provide an assurance statement. Companies are recommended to conduct quality assurance through an audit of their inventory by a third party; see Chapter 19 on the assurance process for details.

Such QA/QC procedures should facilitate the improvement of data quality over time. For example, the *Global GHG Accounting and Reporting Standard* from the Partnership for Carbon Accounting and Financials (PCAF) contains a data quality scoring system that companies can use to develop a data improvement roadmap and track progress over time.[3] QA/QC can also be reported qualitatively, by describing how a dataset is relevant to a company's activity, and highlighting potential pathways for improvement.

6.4.4.2 Evaluating secondary and proxy data and filling data gaps

Where primary data is not available, secondary data can be used, which consists of average data that is not collected from or representative of specific activities within a company's operations or value chain, but is used as a representative proxy of the company's activities. When evaluating and selecting secondary data, companies should assess the data against the same quality indicators in Table 6.8. Where uncertainty between data sources exists, conservative assumptions and values should be used (i.e., values that are more likely to overestimate emissions and underestimate removals).

When available secondary data do not meet a company's quality criteria, they may use proxy data to fill any remaining gaps. This proxy data should also be considered against the quality indicators. For example, if there is no or low-quality data available for a dairy product produced in Germany, but there are high-quality, peer-reviewed data for that dairy product produced in Denmark, a company sourcing dairy from Germany may decide to use the higher-quality proxy data from a different but comparable geographic region, and disclose and justify the choice of proxy.

6.4.4.3 Calibration and validation of models and remote sensing-based approaches

Calibration is the process of refining a model's structure or parameters to improve estimates for a given application, based on measured values specific to that application. This *Standard* recommends that model-based and remote sensing-based calculation approaches should be calibrated using empirical data specific to the land area, management practices, and GHG impacts (i.e., carbon stock changes or GHG emissions) under analysis. In this way, calibration can help ensure estimates of emissions, removals, and other metrics and their associated uncertainty are relevant to the climate, ecology, land use, and land management practices within the land area under analysis.

To evaluate the performance of calibrated models, companies using model-based or remote sensing-based calculation approaches should validate their model estimates against measured values. It is good practice to use a separate dataset, independent of the calibration data, to validate the model and evaluate its performance. Model validation can inform if the model needs recalibration or modifications, or if a different model or calculation approach is warranted.

6.4.4.4 General guidance on estimating uncertainty

Uncertainty is inherent to the use of any data or calculation approach and can be analyzed quantitatively and/or qualitatively. Estimating and documenting sources of uncertainty can assist companies in understanding the steps needed to improve the quality of inventory information and increase the level of confidence users have in that information.

The main types of uncertainty include:

- **Scenario uncertainty**: This occurs when there are different options for implementing a certain calculation that may derive from different conceptualizations of a system, each of which would yield different results. This type of uncertainty can stem from different assumptions about the system (e.g., the selected scope 3 spatial boundary used to estimate net land carbon stock change relevant to the company's scope 3 activities), lack of completeness (e.g., exclusion of certain carbon pools) or bias from the use of proxy data or other data not fully representative of the system to help fill data gaps. Companies can assess this type of uncertainty with a sensitivity analysis, which calculates the range of values possible under the various scenarios. Selecting the most relevant and highest-quality data can minimize this type of uncertainty. Narrowing down the potential scenarios to ones that are most likely to occur will lead to more accurate calculations.
- **Methodological uncertainty**: This stems from the use of models or other methods with built-in assumptions that are not widely relevant. This type of uncertainty can stem from bias and random error in the methods or model used to estimate the value, random error in the methods used to extrapolate or interpolate missing data, and random errors in the statistical methods used to propagate input data uncertainty. Models are simplified representations of physical processes and may exclude or simplify certain components in

order to focus on one specific process. While this may be useful to learn something about the process in question, including the foregone components may lead to different results, and thus introduces modeling error. For example, a company may model fruit tree growth in an orchard using a constant growth rate as an approximation for annual biomass carbon stock increases, when fruit tree growth is more accurately represented by an "S curve." While the linear growth rate can serve as a good approximation for the carbon stock increases, it introduces some methodological uncertainty. This type of uncertainty can be addressed by improving the extent to which a model reflects the processes in question and validating models to assess the need for recalibration or modifications.

- **Parameter uncertainty**: This occurs from measurement error or inaccurate approximation. This type of uncertainty can stem from the inherent variability of the system being quantified, random errors based on sampling or inventory design, random errors from measurement technique or calibration, and random errors or bias in estimates obtained from expert judgement. Parameter uncertainty leads to incomplete knowledge of the "true" value and how well it fits the required use. For example, a national emission factor that is applied to a particular farm might be an over- or underestimation for that farm. This type of uncertainty can also be introduced due to measurement error in direct physical measurements in situ, such as an error associated with a measurement device. Measurement error is most relevant for activity data, emission factors, removal factors, and other data obtained using direct measurements. This type of error can be statistically quantified using a probability distribution with standard deviations and can be addressed by improving data quality.

Qualitative uncertainty assessment approaches include an analysis of shortcomings of data collection methodology or potential model errors that may have occurred in the calculation process. For example, a qualitative uncertainty assessment might include comments on the geographical or temporal relevance of the data or might discuss how a process-based model oversimplifies the physical processes being analyzed. For more information on estimating qualitative uncertainty, see the GHG Protocol *Policy and Action Standard*.[4]

Quantitative uncertainty assessment approaches involve estimating an uncertainty range based on the parameter uncertainty, scenario uncertainty, and model uncertainty. The uncertainty range is the range of plausible values, for a specified confidence level, that are expected to contain the true value for the estimate. It is possible to quantify the uncertainty and error of calculations in several ways. For example, error propagation quantifies the combined impact of the uncertainty of all parameters in a calculation. Error propagation begins with assessing single-parameter uncertainty, which can be conducted via:

- Default uncertainty values from the literature or a commercial database
- A survey of experts to estimate an upper and lower bound
- Probability distributions and standard deviation

Alternatively, Monte Carlo simulations are a method of assessing error propagation that determines the probability of parameter values using random sampling. The uncertainty associated with each parameter is calculated as a probabilistic distribution, and the simulation takes many randomized combinations of potential values of individual variables to produce an uncertainty range for the assessment as a whole. For further information on uncertainty, see the *Scope 3 Standard* (Appendix B)[5] and the *Policy and Action Standard* (Chapter 12) and the *IPCC Guidelines for National Greenhouse Gas Inventories, Volume 1, Chapter 3*.[6]

Uncertainty is just one of several elements required to evaluate data and methods. Companies should consider how the benefits of assessing and addressing uncertainty can complement, or present tradeoffs, with other business goals. For example, reducing uncertainty in data collection and analysis can be costly (e.g., in terms of time and resources). Some types of uncertainty (e.g., biased estimates) are often more problematic than others (increased standard deviations), depending on the context. When pursuing increased accuracy alongside other business goals, companies should ensure that the amounts of each type of uncertainty are low enough to support the intended use of the data.

6.4.5 Scope 3 allocation of emissions, removals, and other metrics

Allocation is the process of partitioning impacts such as GHG emissions, removals, or other metrics from a common process, facility, or other system among its various outputs. Allocation is used to estimate an emission factor, removal factor, or other metric that corresponds to the reporting company's scope 3 activities, to account for the scope 3 emissions, removals, or other metrics attributable to those activities.

Allocation is necessary when the impacts of a system are quantified for the system in its entirety, instead of separately for each of the outputs of that system, either due to methodological limitations or because the impacts of the outputs do not occur in isolation. Multi-output systems can exist at different tiers of a value chain (e.g., at the land that produced the relevant raw good or material, at a processing facility, etc.). For example, allocation is needed to divide the total emissions, removals, and other metrics attributable to the productive land in a cropping system across the outputs of that system (e.g., soybean and corn in a crop rotation). Likewise, allocation is also needed to divide total impacts attributed to the raw soybean amongst the outputs of a relevant processing system (i.e., co-products and by-products, such as soybean oil and soybean meal).

Allocation is not necessary if a system produces only one output, and allocation can be avoided if emissions, removals, or other metrics that result from the production of each output are separately quantified. For example, to avoid allocation within one farm that produces multiple crops, data could be generated separately for each field producing individual crops or each set of fields producing similar crop types. Allocation for waste or recycled material is not needed (see guidance in Section 6.4.5.3).

Allocation is relevant in instances when a company is using primary data to calculate emissions, removals, or other metrics for a specific facility, land area, or other asset with multiple outputs. Allocation is generally less relevant when a company applies secondary data, particularly life cycle emissions factors, as the secondary data provider (e.g., database, researcher) is likely to *already* have applied an allocation approach when publishing a factor for a given intermediate or final product. Even if the reporting company is not calculating the allocation step directly, the allocation recommendations in Section 6.3 of the *Standard* can inform the selection of the most appropriate secondary data, for instance, from a database, to ensure common allocation approaches are applied. This *Standard* recommends that companies ensure that the same emission allocation methods are used for each facility or system within a value chain to avoid the over-counting or under-counting of total emissions, in accordance with the *Scope 3 Standard*. Companies must also ensure that allocated removals do not exceed total removals in the system, as set forth in Requirement 22 in Chapter 12.

To allocate impacts for the land sector, different allocation approaches can be applied to identify emissions, removals, and other metrics that correspond to outputs of a system relevant to the value chain of a company. Allocation approaches can be based on the physical properties of the outputs (e.g., the relative mass of two co-products), the economic market value of the outputs, or other characteristics of the outputs that have a relationship to the emissions and removals resulting from the common process (e.g., the area and time a given land area is used to grow different crops in a cropping system). Different allocation approaches are appropriate under different circumstances.

Note that, when accounting for LUC emissions using the statistical land use change (sLUC) calculation approach, proxy information is used to allocate total land use change emissions in a scope 3 spatial boundary to products produced in that spatial boundary (see Chapter 7). This particular allocation method and its application for LUC emissions accounting is unique and distinct from the application of allocation methods discussed here in Chapter 6 (e.g., economic or physical allocation methods) to partition the emissions, removals, and so on, from a system to the outputs of that system. See the section "Allocation of land use change (LUC) emissions across products" in Section 6.4.5.2 and Chapter 7 for further guidance.

6.4.5.1 Selecting an appropriate scope 3 allocation approach

Selecting an appropriate allocation approach depends on the type of system and the relationship between the quantified impacts and the outputs. The impact of a product could be connected to its physical characteristics, its economic value, and/or other factors. For example, the impact of cleaning, peeling, or dehulling equipment could be related to the economic value of the product that is driving and defining that process; the impact of a fertilizer could be related to the area of land that each crop is occupying and for how long; and the impact of a storage facility could be related to the volume of the products it contains. The "Scope 3 allocation recommendations" in Section 6.3 of the *Standard* set forth the principles that should be considered when selecting an allocation approach.

Alignment on the use of an allocation approach among all entities in the value chain of a given system is essential to prevent over- or undercounting the impact of that system, which can occur when different allocation approaches are applied for each of the outputs. For example, under-allocation of emissions can occur if two companies sourcing animal co-products from the same slaughterhouse apply different allocation methods, particularly if they each apply a method that allocates fewer emissions to the co-product they source. If one company that sources bones and non-edible organs uses economic allocation (e.g., using a 10 percent economic allocation ratio based on the relative market value of all by-products), and another company that sources the meat uses physical allocation (e.g., using a 55 percent allocation ratio based on the relative mass of meat), there is a risk that some (e.g., 35 percent) of the emissions associated with raising the beef cattle are unaccounted for across the two companies that source from that slaughterhouse.[7]

The "Scope 3 allocation recommendations" in Section 6.3 in the *Standard* provide a decision tree to guide companies in selecting an appropriate allocation approach. The first step in this decision tree recommends avoiding allocation, if possible. The following steps recommend aligning with allocation methods set forth in legislative requirements or sectoral recommendations, to promote alignment among companies that are responding to a similar context or that potentially are a part of a common system. Following that, the decision tree includes steps to consider the different allocation approaches, such as physical or economic allocation, as recommended in the *Scope 3 Standard*. Further guidance for the first three steps in this decision tree is provided here:

- **Avoid allocation**: When possible, allocation should be avoided to circumvent assumptions that are inherent to the selection of any allocation approach. Allocation can be avoided in the following circumstances:
  - A system only produces one output (e.g., a farm that produces a single variety of rice).
  - A system produces multiple outputs, but each output is produced in distinct subunits with corresponding data (e.g., a farm that produces multiple crops, but the specific field can be differentiated for each crop, and data is available to generate field-level emissions estimates).
- **Legislative requirements**: Multiple companies involved in allocating emissions, removals, and other metrics from a single process should use consistent allocation methods between them. Jurisdictional laws or regulations or intergovernmental sector recommendations can require or recommend the comparable and consistent accounting of emissions, removals, and other metrics between companies and over time. Companies should follow any laws or regulations that are applicable to their sector or sourced commodity.
- **Sectoral recommendations**: The allocation approach that best adheres to the recommended principles will depend on the system or process, and the sector and/or commodity. Allocation can occur at different tiers in the value chain, and different allocation approaches can be appropriate at different tiers. The most appropriate allocation method for a given activity is the one that best reflects the causal or functional relationship between the production of each product (or primary product and its co-products) within a system and the resulting emissions, removals, or other metrics. For example, the emissions resulting from production could be directly related to the economic value of the product that pays for that process. After seeking to align with legislative requirements, companies should follow sectoral recommendations that have been developed through an inclusive multi-stakeholder process, when available. This *Standard* provides general allocation recommendations for the agriculture sector, which are discussed further in Section 6.4.5.2.

In addition to following legislative requirements and sectoral recommendations, companies can ensure consistent allocation across the value chain through contractual agreements or other mechanisms. Where supply chain traceability is limited, this will be a challenge, but companies should work towards comparable allocation methods across companies and consistent allocation methods over time. In line with the conservativeness principle and to avoid the under-reporting of emissions or over-reporting of removals, companies can establish agreements between the various entities reporting direct and indirect emissions and removals that specify which company (or companies) account for what proportion of emissions and removals.

For example, if a plantation is growing both coffee and fruit trees, companies purchasing the coffee and the fruit need to use the same allocation approach to allocate the removals occurring on the plantation among the coffee and the fruit produced on that plantation. If the relevant production system generates 100 tonnes (t) CO_2 removals, the multiple companies sourcing coffee and fruit must avoid collectively reporting more than 100 t CO_2 removals (see Requirement 22).

6.4.5.2 Agriculture sector allocation recommendations

Section 6.3 in the *Standard* provides general "Agriculture sector allocation recommendations" which encourage increased standardization and comparability of allocation methods among land sector companies and within agricultural systems. These recommendations for the agriculture sector provide specific guidance for allocation decisions that characterize certain tiers in agricultural value chains (i.e., allocation at the land or allocation at the product processing facility).

- **Allocation at the land**: This may be necessary when an LMU or sourcing region produces multiple agricultural products as part of a cropping system. Production of these agricultural products could be sharing the same land either simultaneously or asynchronously during a defined time period. Where different agricultural products are generated on the same LMU and benefit from the same inputs, physical allocation is not recommended. Companies are recommended to first follow the guidance below for a specific cropping system (if applicable), and then follow the "hierarchy of land allocation methods among agricultural products" in Section 6.3.
  - **Crop rotations**:[8] A crop rotation is a practice of growing alternating crops in a repeating sequence or pattern on the same land, within a year or across years. Because the same production activities (e.g., soil preparation, amendments, etc.) are involved in the production of multiple crops in the rotation, it may be difficult to isolate the impact that each crop has on the GHG emissions, removals, and other metrics attributable to the rotation system. For example, the N_2O emissions associated with N fertilizer applied to a particular crop in a rotation could be released after that crop is harvested, and as a subsequent crop is growing. Companies are recommended to calculate carbon stock changes and other GHG emissions over the full crop rotation and then allocate those emissions across all crops in the rotation.
  - **Crop rotations with cover crops**: Cover crops can be planted in a crop rotation system or between other crops, often to protect soil from erosion or nutrient depletion. Cover crops (or other non-cash crops, including temporarily fallow land) typically have low or no market value and are included in the cropping system to sustain or enhance the productivity of the cash crop(s). The market demand of the cash crop(s) is assumed to largely determine the impacts of the agricultural cropping system. Therefore, it is recommended that companies allocate net land carbon stock changes and other GHG emissions associated with cover crop production (or other non-cash crops, including temporary fallow land) across all cash crops in the crop rotation, or to the subsequent cash crop if not part of a crop rotation with multiple cash crops. This allocation approach may also apply to agroforestry systems which include plants or trees that are not associated with the harvested product.
  - **Intercropping**: Intercropping is when more than one crop is grown on the same land at the same time. Companies should follow the allocation principles and the "hierarchy of land allocation methods among agricultural products" in Section 6.3.
- **Allocation at the agricultural product processing facility**: Allocation at a processing facility can be necessary when one product is processed into a primary co-product and other secondary co-products or by-products. The market value of the primary co-product can be significantly higher than the market value of its secondary co-products; therefore, economic demand for the primary product is considered to determine the impact of the relevant system. If multiple co-products are generated from the same agricultural product at a processing facility, companies should allocate based on the share of the total economic value for each co-product.

ALLOCATION APPROACHES AMONG AGRICULTURAL PRODUCTS

In most agricultural systems, market demand determines production, and in an open market, agricultural commodity prices significantly influence production. Therefore, it is recommended that impacts within agricultural systems are allocated based on the economic value of the agricultural outputs (i.e., economic allocation), unless a more appropriate method is justified. Economic allocation is commonly used in agricultural product life cycle analysis and is generally the default allocation method in agricultural product LCA databases, especially when partitioning between crop co-products.[9]

There are also limitations to the economic allocation principle, as it assumes that the various actors in the production system act rationally (e.g., market price is a key driver of the producer's land use decisions and informs which agricultural products are grown). Market prices can also be volatile. To apply an economic allocation method, the economic value of each output (e.g., agricultural product) from a system must be known or estimated. Price data is readily available for many agricultural products, but this information may not be available for some products in some regions, especially secondary co-products and by-products, and in these cases, proxy data is generally used. In some cases, additional decisions may be needed to apply economic allocation. For example, if a cropping system produces coffee (sold on the market) and also cassava (for the farmers' consumption), a judgment must be made regarding the relative economic value of these outputs. Economic allocation methods can also differ in terms of the specific proxy (e.g., based on the average market price or the producer's specific sale price).

The choice of one allocation method or another determines the emissions, removals, and other metrics attributable to a product or material, and therefore can have a significant influence on the information reported in the scope 3 inventory. Companies that have a choice between multiple methods for a given activity should evaluate each method to determine the range of possible results, and to promote transparency, companies can report the range of results produced by different allocation methods (i.e., a sensitivity analysis).

- **Economic allocation**: Economic allocation partitions emissions, removals, or other metrics based on the price of a product relative to the price of all other products from a given system. This method uses the market value of the various products as a proxy for the share of the emissions intensity for each output of the system. Economic allocation is appropriate when price is a key driver for a producer's decision-making regarding production and land management activities. This allocation principle assumes the system is driven by the demand for one or more products, and therefore, the impact of each product is proportionate to its market value.

For example, consider a company that sources soybean oil. To account for the emissions, removals, and other metrics due to activities in the soybean oil value chain, allocation is needed to divide the impacts attributable to the production and processing of soybeans across the outputs of systems at different tiers in the value chain. First, the reporting company may need to use allocation to divide the emissions, removals, and so on, associated with a cropping system across the multiple outputs of that cropping system (e.g., soybean, maize, etc.). Companies should first follow the guidance above for "allocation at the land" and then apply an allocation method. Using economic allocation, a company allocates emissions from the cropping system across the outputs of the system based on their relative market value.

Economic allocation at the farm-level (i.e., "at the land") requires price data for all the outputs of a given cropping system. The price data used should reflect the average market price during the period under consideration. This is in line with the yield data used, which also represent the average yield during the period under consideration. The following data should be collected:

- Total production in the relevant time boundary (e.g., kilograms of soybeans and other outputs of the system)
- Price per kilogram, for each output of the system (i.e., product type)
- Emissions, removals, and other metrics from the agricultural (e.g., cropping) system

In the soybean oil example above, allocation is also needed at the point of processing (i.e., where raw soybeans are processed into crude soybean oil, soybean meal, and other co-products and by-products). For example, the processing facility provides the reporting company with the following data: one tonne of soybeans produces 0.2 tonnes of soybean oil and 0.8 tonnes of soybean meal, and the market value of the oil is US$1 per kg, and the market value of the meal is $0.30 per kg. Using economic allocation, the upstream emissions attributed to the production of the raw soybeans (inclusive of the processing emissions from the processing facility itself) are allocated to the oil and meal based on the relative market value of these co-products.

- **Area–time allocation**: Area–time allocation partitions emissions, removals, or other metrics based on the amount of land area used and the duration it is occupied. This approach allocates the same GHG emission impact from the agricultural system to each square meter-year (m^2a) of productive land where the land-based product in the agricultural system is grown. Therefore, area–time allocation may be appropriate when allocating "at the land" (e.g., allocating emissions, removals, land occupation, etc., across the outputs of a cropping system; see "allocation at the land" above).
- **Physical allocation**: Physical allocation partitions emissions, removals, and other metrics based on a physical attribute (e.g., mass, volume, energy, etc.). Applying physical allocation can be appropriate when the physical properties of the product and co-products that are outputs of the system determine the emissions, removals, and other metrics of the system. For example, this method can be appropriate in systems where the physical attribute is a reasonable proxy for emissions intensity (e.g., heavier or larger products are responsible for more emissions associated with transportation or storage). Note that the results of mass allocation can differ significantly depending on whether the allocation calculation is based on wet or dry mass. For transparency, if mass allocation is applied, companies should report whether the allocation was based on wet or dry mass.

ALLOCATION OF LAND USE CHANGE (LUC) EMISSIONS ACROSS PRODUCTS

When accounting for LUC emissions using the statistical land use change (sLUC) calculation approach, proxy information is used to allocate total LUC emissions in a scope 3 spatial boundary to products produced in that spatial boundary. The required allocation approach is called the product expansion allocation method (see Section 7.4.6 for guidance). This particular allocation method and its application for LUC emissions accounting are unique and distinct from the application of general scope 3 allocation methods (e.g., economic, physical, etc.) discussed here in Chapter 6 that are used to partition the emissions, removals, and so on, from a system to the outputs of that system. When allocating scope 3 LUC emissions at the land (i.e., across different crops produced within multi-product agricultural systems) using the direct land use change (dLUC) calculation approach, the allocation approaches and methods discussed here in Chapter 6 can be applied to allocate LUC emissions. The allocation methods discussed here in Chapter 6 can also be applied to allocate scope 3 LUC emissions between co-products (e.g., soybean oil and soybean meal) when using either the dLUC or sLUC calculation approaches.

6.4.5.3 Allocation approaches for waste and recycled material

ALLOCATION APPROACHES FOR WASTE PRODUCTS

Waste is an output of a process or system that has no market value. If waste is an output of a process or system, no emissions, removals, or other metrics should be allocated to the waste.

For example, an agricultural company that sells fruits and nuts may also generate orchard trimmings and other agricultural residues as waste. A bioenergy company could source the orchard residues from the agricultural company but does not pay for these waste materials. When the bioenergy company compiles its GHG inventory, it accounts for and reports zero upstream lifecycle GHG emissions, removals, and other metrics attributable to the land management and/or production processes of orchard production. In other words, the company sourcing agricultural waste should not account for any upstream indirect emissions, removals, or other metrics associated with waste within their scope 3 inventory, prior to the generation of the waste. Instead, all the land emissions and removals are allocated to the fruits and nuts (and other outputs of the orchard system that do have market value) produced on the orchard. If waste becomes useful and marketable for use in another system, it is no longer considered waste and must be treated likewise in the reporting company's accounting (i.e., allocated upstream lifecycle GHG emissions based on the economic or other relevant allocation methods).

This allocation approach for waste does not apply, however, to scope 3, category 5 (Waste generated in operations) or scope 3, category 12 (End-of-life treatment of sold products). Companies must account for all emissions related to waste within scope 3, categories 5 and 12. For example, if a company that processes chicken meat generates waste (e.g., offal, feathers, organic solids) that is sent to landfill or wastewater treatment facility, the company must account for the CH_4 emissions associated with decomposition at the landfill or other facility in their scope 3, category 5. Emissions and other impacts related to losses or waste that occurred upstream to the purchase of a product must be accounted for in scope 3, category 1 (purchased goods and services), as noted in Requirement 3.

Companies may use the recycled content allocation method below for allocating impacts to post-consumer waste that is recycled (e.g., used cooking oil, recovered fiber) or reused (e.g., material/residue that is reused as a material input into another process) regardless of the market value of the waste. Companies that apply this allocation approach are required to report evidence that the waste is post-consumer and that the waste has been reused or recycled.

ALLOCATION APPROACHES FOR RECYCLED PRODUCTS

Under the recycled content method, the life cycle of recycled materials is assumed to start with the recycling process. Therefore, to avoid double counting of emissions, the company providing the material to be recycled accounts for emissions from recovering materials at the end of their life for recycling in scope 3, categories 5 and 12. The company obtaining recycled materials accounts for upstream scope 3 emissions from the recycling processes in scope 3, categories 1 and 2.

For example, if a company uses recycled cotton fiber to make clothes, the reporting company accounts for the emissions associated with the recycling process in their scope 3 category 1, such as the emissions from shredding the cotton back into fiber. The reporting company would not have to account for the emissions upstream to the recycling, such as land emissions (or removals) from growing the cotton or emissions from the first processing facility that cleaned the cotton from seeds.

Companies must not report negative or avoided emissions associated with recycling in scope 1, scope 2, or scope 3. Any claims of avoided emissions associated with recycling must not be included in, or deducted from, scope 3 emissions, but may instead be reported separately from the physical GHG inventory. Companies that report avoided emissions should also provide data to support the claim that emissions are avoided (e.g., that recycled materials are collected, recycled, and used) and report the methodology, data sources, system boundary, time period, and other assumptions used to calculate avoided emissions. For more information on avoided emissions, see Section 9.5 of the *Scope 3 Standard* and Chapter 16 of this *Standard*.

Endnotes

1 In some regions, legislative requirements on data protection and farmer protection might prevent companies from accessing or sharing some of these data. Established regulations regarding disclosures (e.g., anti-trust regulations, data privacy laws) take precedence over this requirement.

2 Adapted from Szebiotko (1985).

3 PCAF 2020.

4 WRI and WBCSD (2014a), Chapter 12, Section 12.6. Available at https://ghgprotocol.org/policy-and-action-standard.

5 Available at https://ghgprotocol.org/standards/scope-3-standard.

6 Available at https://ghgprotocol.org/policy-and-action-standard and https://www.ipcc-nggip.iges.or.jp/public/index.html.

7 These examples for average economic and mass allocation ratios are derived from Kyttä et al. (2022).

8 Cropping system definitions are derived from USDA (2024).

9 See, e.g., Agri-footprint Database, World Food LCA Database, etc.

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