# Measure the Chain: Tools for Assessing GHG Emissions in Agricultural Supply Chains


Report by

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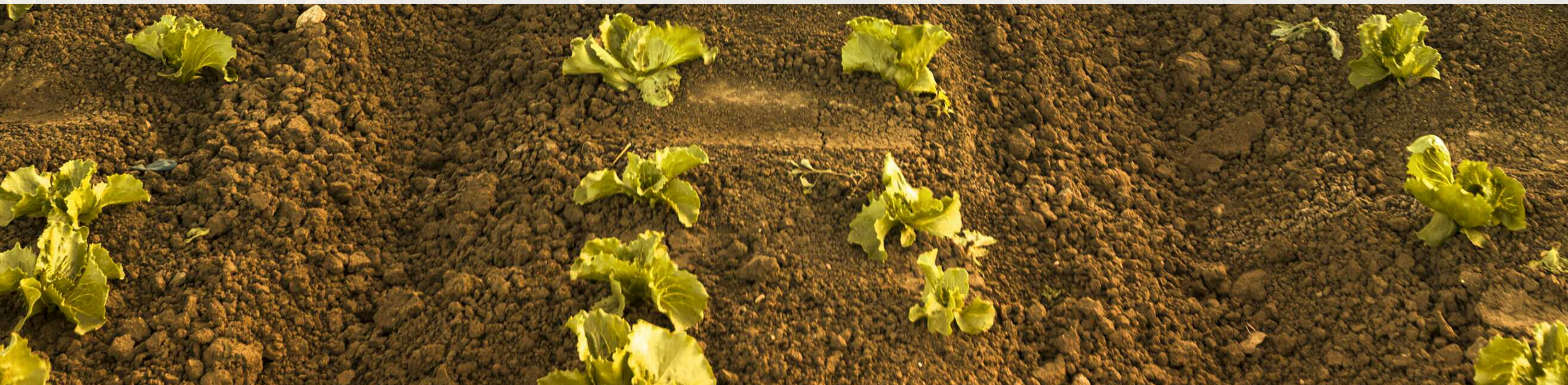

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Support for this series was provided by the Gordon and Betty Moore Foundation as part of a conservation and financial markets collaboration among Ceres, World Wildlife Fund and World Business Council for Sustainable Development.

The CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS) is carried out with support from the CGIAR Trust Fund and through bilateral funding agreements. For details please visit this website.

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We would also like to thank our colleagues at Ceres who provided extensive support with the project, including Dr. Julie Nash, George Grattan and Tessa Castellani. We would also like to thank our consultant, Gillian Lui, for her support on this research.

## EXPERT REVIEWS

Our thanks to the following individuals who generously shared their time and expertise to review and provide feedback on the report content:

Dr. Sultana Bashir, Director, Forests, CDP
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Members of the Ceres team also conducted external consultations with representatives from Blonk Consulting, SouthPole Group, and Quantis to gain further insight into their respective emissions calculation tools. Ceres integrated information gleaned from these consultations into this report and endeavored to reflect these tools and their capacities as accurately as possible and to the best of our abilities. We thank the representatives of these groups with whom we met for their willingness to share their knowledge and time.

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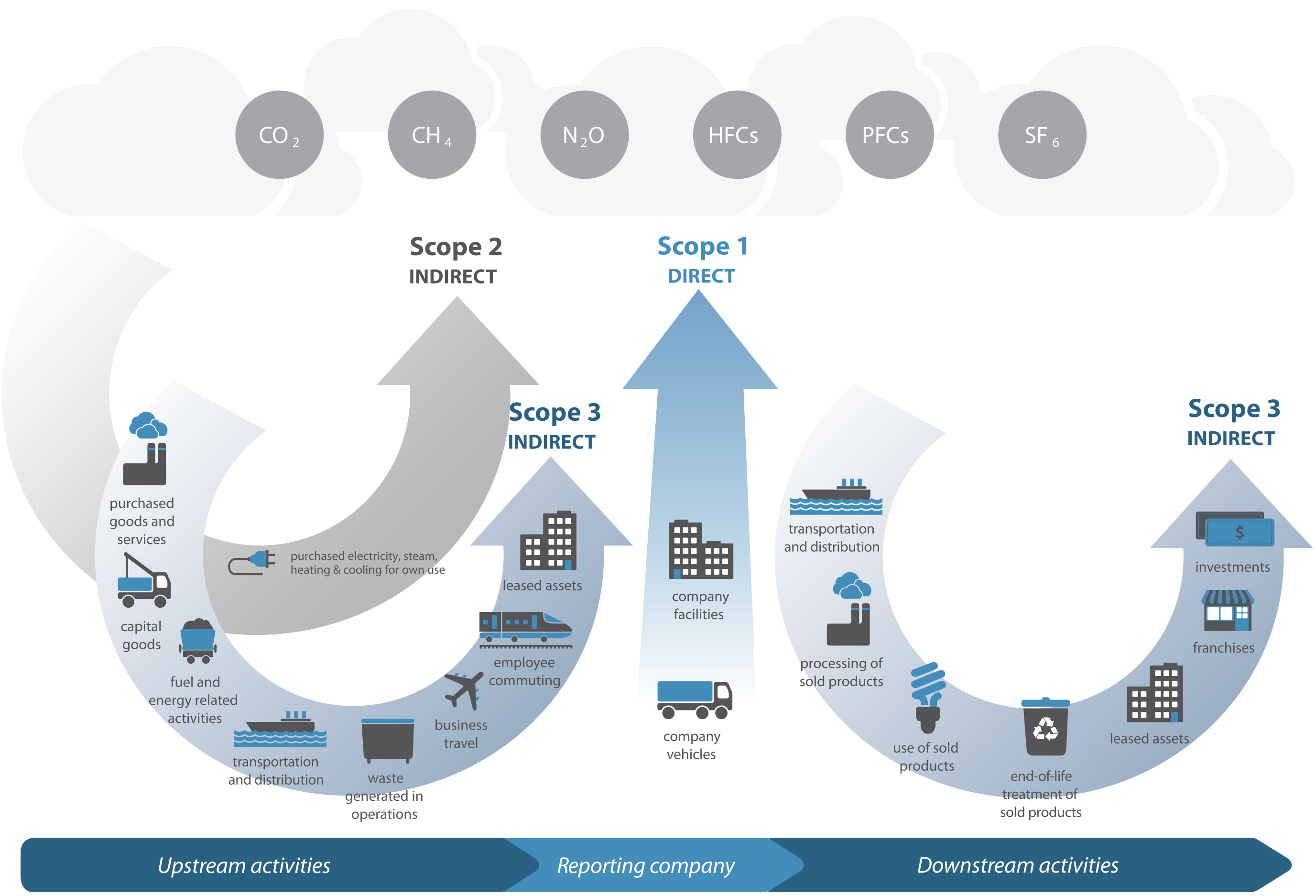
# Report background

**Climate change poses a number of risks to food and agricultural companies that impact their corporate performance and long-term value creation. Land use change (LUC) from commodity crop and subsistence agriculture, particularly in Latin America and Southeast Asia, where the production of beef, soy, palm oil and cocoa have led to 87 percent of all tree cover loss between 2001and 2015, have an outsized impact on greenhouse gas emissions (FAO, 2016). Of the emissions generated by food systems, most—over 80 percent—stem directly from agricultural production and its associated land-use change (Vermeulen *et al*., 2012). For most food and agricultural companies, these emissions are considered "scope 3" emissions: upstream or downstream emissions not under direct control of the company (i.e. indirect emissions) (Figure 1). While many companies have for some time estimated and reported greenhouse gas emissions (GHG) from company facilities, company vehicles and purchased electricity (i.e. scope 1 and scope 2 emissions), companies are increasingly recognizing the importance of also measuring and disclosing their scope 3 emissions.**

## FIGURE 1. SCOPES AND EMISSIONS ACROSS THE VALUE CHAIN




*Source: The Greenhouse Gas Protocol (WRI and WBCSD, 2001).*

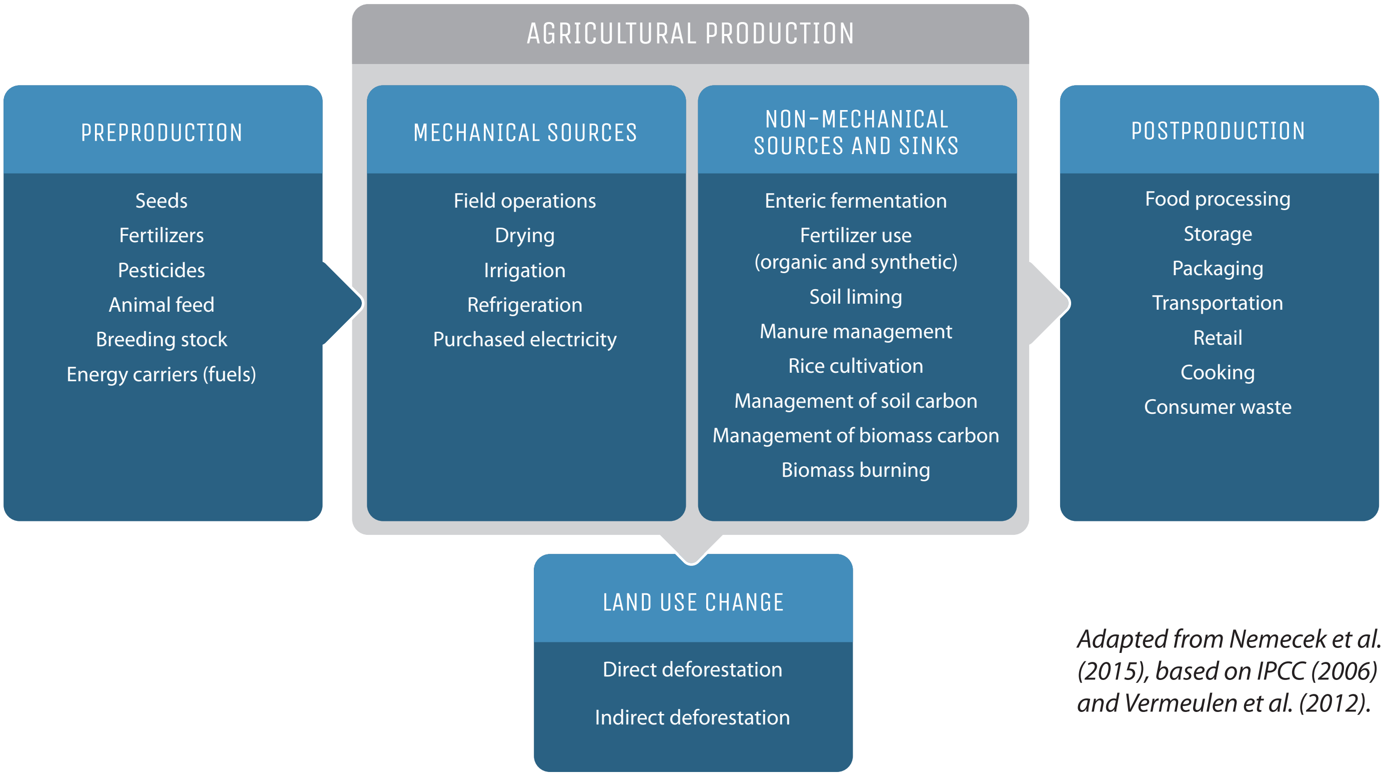
Measuring emissions from agricultural production and LUC within corporate value chains is both essential and difficult. Agricultural emissions are driven by complex interactions between natural and human processes, and estimating these emissions with any accuracy requires data on agricultural management, soil, and climatic factors at the site of production. For a company producing multiple products and sourcing from potentially thousands of producers, collecting such data can be daunting.

This report provides an overview of available resources (i.e. standards, methodologies, tools, and calculators) for assessing emissions from agricultural production and agriculturally-driven LUC. Resources were assessed in terms of how they could help companies track progress on reduction targets for agricultural emissions. The collection of tools and approaches included in this report was assembled from: company reports to CDP; conversations with companies attending a March 2018 workshop on metrics for climate-smart agriculture hosted by the World Business Council for Sustainable Development (WBCSD) and the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS); conversations with service providers in the GHG accounting field; published reviews of agricultural GHG accounting tools; and the authors' previous knowledge. The report is limited to tools and approaches specific to agricultural commodities, with a limited discussion on the most widely used frameworks for corporate GHG inventories generally.

## SOURCES OF GHG EMISSIONS FROM THE PRODUCTION AND PROCESSING OF AGRICULTURAL PRODUCTS

GHG emissions are generated by activities in all stages of the food system. **Pre-production emissions** result from manufacture and distribution of agricultural inputs such as seeds, fertilizers, pesticides, animal feed, and maintenance of animal breeding stock **(Figure 2)**. Emissions from **agricultural production**, sometimes referred to as "on-farm" emissions, can be separated into mechanical and non-mechanical sources (WRI and WBCSD, 2014). **Mechanical sources**

## FIGURE 2. SOURCE OF GHG EMISSIONS FROM PRODUCTION AND PROCESSING OF AGRICULTURAL PRODUCTS




*Adapted from Nemecek et al. (2015), based on IPCC (2006) and Vermeulen et al. (2012).*

are the operation of equipment or machinery on farms, such as harvesters and refrigeration equipment. These sources emit carbon dioxide ($CO_2$), methane ($CH_4$), nitrous oxide ($N_2O$), hydrofluorocarbons (HFCs), and perfluorinated chemicals (PFCs). Emissions from these sources are determined by the characteristics of the equipment and fuel composition. In contrast, emissions from **non-mechanical sources** are the result of biological and biogeochemical processes such as enteric fermentation (digestion of carbohydrates by ruminants such as cattle), decomposition of organic matter, and nitrification and denitrification in soils (WRI and WBCSD, 2014). These emissions (of $CH_4$, $N_2O$, and, to a much lesser extent, $CO_2$) are shaped by climatic and soil conditions as well as by agricultural management decisions. Post-production emissions include emissions from activities such as food processing, storage, packaging, transportation, and retail processes. Further sources of emissions occur past the point of the consumer's purchase of the product, such as from cooking and consumer waste.

In addition to being sources of GHG emissions, farms also have the potential to act as "sinks" for $CO_2$—in other words, functioning to remove carbon from the atmosphere and store it in soils or woody vegetation (trees and shrubs). When this storage happens permanently, representing a genuine, long-term transfer of additional carbon from air to soil or biomass, it is referred to as carbon sequestration. This report generally uses the term "carbon stock change" to refer to increases or decreases in carbon stocks in soils or trees.

## SOURCES OF GHG EMISSIONS FROM LAND USE CHANGE

Agriculture is also a driver of LUC, directly responsible for a significant proportion of deforestation worldwide. Emissions due to LUC include those from loss of carbon stocks—in the form of $CO_2$ emissions—in five main carbon pools: aboveground biomass, belowground biomass, soil organic carbon, litter, and dead wood—the latter two of which may be combined into one category of "dead organic matter."

If vegetation is burned, additional $CO_2$, $CH_4$, and $N_2O$ emissions may be generated. Intergovernmental Panel on Climate Change (IPCC) (2006) guidelines recognize LUC as a conversion between any of five land-use categories: forest, cropland, grassland, wetland, and settlements. However, because deforestation (i.e. conversion of forest to cropland or grassland) is often the LUC of largest global impact and of primary concern for companies, the selection of resources described in this report deals primarily with monitoring deforestation.

In attributing LUC to a particular agricultural product, companies often distinguish between *direct* and *indirect* LUC. This distinction originated in international guidance for reporting on emissions from land use, land use change and forestry (LULUCF) under the Kyoto Protocol (IPCC, 2000). Direct LUC, as the name implies, is directly attributable to the product in question: the impact happened on the field where the product was grown (or grazed). Indirect LUC happens at the market level, when global demand for more product leads to land being converted to agriculture. These "direct" and "indirect" categories shown in Figure 2 for LUC emissions are not related to the "direct" and "indirect" labels in Figure 1, which have to do with emissions directly under the control of a given company rather than the attribution of LUC.

## SCOPE 3 EMISSIONS FROM AGRICULTURE IN CORPORATE SUPPLY CHAINS

The sources of GHG emissions described in Figure 2 fall under different scopes depending on the operations owned or controlled by a particular company. For most processors, traders, distributors, manufacturers, and retailers, emissions from agricultural production and LUC would be considered scope 3 emissions from purchased goods and services (i.e. emissions embedded in the purchase of raw materials). However, these emissions may fall under scope 1 for vertically integrated food companies and primary producers.

### FIGURE 3. SCOPE OF EMISSIONS FROM AGRICULTURAL PRODUCTION AND LUC BASED ON THE POSITION OF AN OPERATION IN THE SUPPLY CHAIN.

| SUPPLY CHAIN PHASE | TYPE OF COMPANY | | EMISSIONS FROM AGRICULTURAL PRODUCTION AND LUC ARE... |
|---|---|---|---|
| AGRICULTURAL PRODUCTION | PRIMARY PRODUCERS | | SCOPE 1 |
| PROCESSING, TRANSPORT, TRADE, DISTRIBUTION | TRADERS, DISTRIBUTORS, AND MILLERS | MILK AND DAIRY PROCESSORS | SCOPE 3 |
| | ANIMAL FEED PROCESSORS AND PURCHASERS | MEAT PACKERS AND PROCESSORS | |
| MANUFACTURING | PACKAGED FOOD MANUFACTURERS | | SCOPE 3 |
| RETAIL AND CONSUMPTION | RESTAURANTS | RETAILERS | SCOPE 3 |

## GHG QUANTIFICATION

The vast majority of methodologies and tools developed for corporate GHG reporting are based on the reporting guidelines published by the IPCC. The IPCC guidelines were developed to synthesize the best available science on greenhouse gas estimation and are mandated for use by all national governments in reporting to the United Nations climate conventions. Because the IPCC guidelines are the internationally accepted methods for GHG quantification, nearly all greenhouse gas calculators (including those intended for corporate use) make use of these methods. The relevant IPCC volume for agriculture and LUC is *Volume 4: Agriculture, Forestry and Other Land Use*. In 2019, the IPCC plans to release a refinement of the 2006 guidelines, incorporating the latest science on greenhouse gas sinks and sources, called the *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*

Per the methodology established by the IPCC, emissions are generally calculated using the following formula:

***Emissions=activity data×emission factor***

Activity data are data on the magnitude of a human activity resulting in GHG emissions or removals (carbon sequestration) taking place during a given period of time. Data on the kilograms of nitrogen fertilizer applied to an area of cropland is an example of activity data. A corresponding emission factor calculates the quantity of $N_2O$ emissions resulting from that fertilizer application.

Emission factor databases are collections of emission factors that allow GHG emissions to be estimated from a unit of available activity data. Emission factor databases provide emission factors for individual activities, such as the aforementioned application of 1 kg of nitrogen fertilizer. The global standard emission factor database for individual activities is the **IPCC Emission Factor Database**. Maintained by the IPCC, the Emissions Factor Database provides all default tier 1 emission factors as well as tier 2 emission factors that have been deemed of sufficient scientific rigor by a review panel. The database provides factors for all agricultural GHG source and sink categories included in the IPCC guidelines: livestock enteric fermentation, manure management, fertilizer and lime application, paddy rice cultivation, biomass burning, and carbon stock changes associated with LUC or changes in management within an existing land use, such as tillage.

### BOX 1: WHAT IS THE DIFFERENCE BETWEEN TIER 1, TIER 2 AND TIER 3 CALCULATION METHODS?

*The IPCC guidelines provide methodologies at three levels of complexity, called tiers. Tier 1 is the simplest type of method, generally corresponding to the "activity data x emission factor" method described on page 4, using emission factors based on global or regional averages. IPCC provides global default emission factors for every GHG source and sink included in the guidelines. Tier 2 is generally similar to tier 1 but uses country-specific emission factors and more disaggregated activity data. For example, the tier 2 method for estimating emissions from livestock requires data on the number of animals per species disaggregated by life phase, rather than just the total number per species. Tier 3 refers to more complex methodologies such as models and measurement systems. The higher tier the method, the higher the data requirements and the more accurate the estimate of GHG emissions.*

## LCA DATABASES

In the case of corporate accounting, emission factors might also exist at a higher level of aggregation, such as the combined GHG emissions (in CO2 equivalents) generated by the production of 1 kg of bananas in Costa Rica. These product-level emission factors are often calculated as part of product life cycle assessment (LCA) and provided in LCA databases. They reflect the average production conditions for an agricultural product within the geographic area represented by the emission factor. LCA databases differ in where they draw system boundaries (i.e. what GHG sources are included). For example, LUC associated with production of an agricultural product may or may not be included in an LCA emission factor. It is important to understand what is represented in an LCA database emission factor when using it in a GHG inventory.

Two global LCA databases provide emission factors for food products: the **World Food LCA Database** (WFLDB) (Quantis and Agroscope, 2012) and **Agri-footprint** (Blonk Consultants, 2014). These databases provide data on environmental impacts associated with the production, processing, and cooking (in the case of WFLDB) of food and agricultural products. Data are provided at the unit process level—for example, $N_2O$ emissions embodied in 1 kg output fresh (crop) product, unpackaged, at farm exit. These emission factors are based on globally or regionally representative averages for the activities associated with the production or processing of each food product. They generally represent the emissions generated by the "average" technology or practice, as opposed to marginal (old) technology or best practice. Both databases are fairly comprehensive in their coverage of GHG sources and sinks from agricultural production, and both include LUC. The methodology used by WFLDB is consistent with that used by **Ecoinvent**, a large, multi-sector LCA database, and the factors from the first phase of WFLDB development are also available in Ecoinvent. However, access to future additions to the database will require purchase of a specific license for WFLDB. Agri-footprint calculates LUC using the Direct Land Use Change Assessment Tool, described below. Agri-footprint is available within several existing life cycle analysis software packages (which also require purchase of a license).

# Overview of methodologies and tools for measuring scope 3 GHG emissions from agriculture and LUC

**This report reviewed two different types of resources: methodologies and GHG calculation tools. Methodologies include standards, protocols, guidance, and other types of publications that provide recommendations for how to quantify GHG emissions and/or emission reductions from agriculture and LUC in corporate value chains. GHG calculation tools include web-, Excel- or other software-based calculators for quantifying GHG emissions and/or emission reductions (including carbon stock changes) from farms or agriculture and forest-related activities (Colomb *et al*., 2013; Denef *et al*., 2012). This category also includes tools from service providers to estimate emissions from agriculture and LUC, as well as databases and other data sources that companies can use for quantifying emissions and emission reductions.**

## METHODOLOGIES FOR CORPORATE GHG ACCOUNTING

The methodologies most widely used by companies in developing their GHG inventories include the GHG Protocol Corporate Accounting and Reporting Standard (WRI and WBCSD, 2004), the GHG Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard (WRI and WBCSD, 2011), the GHG Protocol Product Life Cycle Accounting and Reporting Standard (WRI and WBCSD, 2011).

- **The GHG Protocol Corporate Standard** is a high-level, cross-sector accounting framework that provides step-by-step recommendations for companies to use in quantifying and reporting their GHG emissions (i.e. when conducting a GHG inventory). It is consistent with the ISO 14064 standards (Baumann and Kollmuss, 2011). The Corporate Standard provides two categories of recommendations: *standards*, or sections describing what is required to prepare and report a GHG inventory in accordance with the Standard, and *guidance*, or suggested principles and methods for preparing an inventory. Companies are required to report all scope 1 and scope 2 emissions but reporting scope 3 emissions is optional. The Corporate Standard provides general guidance on available tools and approaches for calculating GHG emissions and accounting for reductions, but does not suggest any specific calculation methodologies.

- **The GHG Protocol Corporate Value Chain (Scope 3) Standard and Scope 3 Calculation Guidance** complement the Corporate Standard by providing more specific guidance to companies on how to identify, quantify, and allocate emissions in their supply chains. Similar to the Corporate Standard, recommendations are labeled as requirements (in order to be in conformance with the Scope 3 Standard) or guidance.

- **The GHG Protocol Product Life Cycle Accounting and Reporting Standard**, referred to as the Product Standard, provides requirements and guidance for inventories of GHG emissions and removals associated with a specific product. It accounts for life cycle emissions at an individual product level. The Product Standard complements both the Corporate Standard and the Scope 3 Standard. For example, companies might use the Product Standard to calculate product-level GHG emissions in order to incorporate into a scope 3 inventory. Or, after using the Corporate Standard and Scope 3 Standard to identify products with the most significant emissions, companies might then use the Product Standard to identify mitigation opportunities within the life cycles of the highest-emitting products.

Two more recent GHG accounting methodologies are specific to agriculture and LUC: the GHG Protocol Agricultural Guidance and the Land Use Change Guidance.

- **The GHG Protocol Agricultural Guidance** (WRI and WBCSD, 2014) complements the GHG Protocol Corporate Standard by addressing some accounting and reporting issues specific to agriculture, such as the influence of environmental factors on agricultural GHG fluxes and accounting for carbon sequestration. Like the Corporate Standard, it does not require specific calculation methodologies. It is intended for use by primary producers or other companies with agricultural operations under their control (such as seed companies) that are seeking to develop GHG inventories of their operations. It may also be useful to processors or manufacturers who work with suppliers to estimate scope 3 emissions.

- **The Land Use Change Guidance** (Quantis, 2018) is intended to resolve inconsistencies among existing GHG accounting standards on how to calculate emissions from land use and LUC in corporate supply chains for agriculture and forest commodities. It is not a standard. Instead, it assembles existing methodological approaches, harmonizes existing approaches on key topics, and fills gaps where needed in order to provide a complete set of guidelines. It is built upon the GHG Protocol Product Standard. By addressing both direct and indirect LUC, as well as emissions associated with land management practices and how they influence carbon storage on land, the guidance goes beyond existing standards on land-use change. It is structured as a set of recommendations emerging from stakeholder dialogues involving multiple companies and NGOs. The recommendations are currently being tested and refined through a pilot phase, and are scheduled to be released publicly by the end of 2018.

## GHG CALCULATION TOOLS

Many GHG calculators that estimate emissions from agriculture and LUC are publicly available. Most of them were developed either to aid national governments in preparing GHG inventories or to estimate potential GHG changes associated with agriculture and forestry development projects. For example, the most widely used tool in service of the latter category is the Ex-Ante Carbon Balance Tool (Ex-ACT), developed by the United Nations Food and Agriculture Organization and used by several large international development organizations to assess the climate change impacts of their projects. Such tools may be useful to food and agriculture companies to examine the impact of pilot mitigation projects within their value chains. However, because they are structured around project interventions, they are unlikely to be used for product- or company-level GHG inventories. For this reason, the discussion of GHG calculators in this report was limited to those intended for product-level or life cycle assessment. The review of calculators was further limited to those with global coverage, although the potential utility of country-specific calculators is discussed below.

Of the available GHG calculators with global coverage, five are most likely to be useful to companies for estimating emissions from agriculture and LUC, and are compared against each other in **Table 1**. Three of these calculate emissions from all or most of the sources of GHG emissions from production and processing of agricultural products outlined in Figure 2: Cool Farm Tool, Agricultural Life Cycle Inventory Generator, and GLEAM-i.

- **Cool Farm Tool** (Cool Farm Alliance, 2010) is a GHG calculator that assesses greenhouse gas emissions and carbon stock changes at the product or farm level, intended for use by agricultural producers and the companies which they supply. It allows the user to calculate the GHG emissions resulting from the production of a crop or livestock product from a given farm in a given year, using activity data input by the user on soil and climate conditions and farm management practices. The emission factors embedded in the tool are primarily IPCC tier 1 factors. The source and sink categories covered by the tool include: fertilizer production, pesticide production, seed production, animal feed production, energy use (field operations, crop production, on-farm processing), fertilizer use, paddy rice cultivation, crop residue management, enteric fermentation, grazing, manure management, transport off farm, and waste water (Hillier, 2013). For crop products, the tool can also calculate changes in soil and biomass carbon due to direct land use change, changes in tillage practices, and growth or addition of trees within or adjacent to the field on which the crop is grown. Output from the tool includes $CO_2$ equivalent emissions and sequestration for the entire farm, by source and product; expressed as total emissions, emissions per area, and emissions per unit product.

- **Agricultural Life Cycle Inventory Generator** (ALCIG) (Quantis, 2015) is a tool that calculates life cycle inventory data for crop products. The tool allows companies to generate custom product-level emission factors using the same methods and background datasets that are used to generate the factors in LCA databases such as Ecoinvent and the WFLDB. Because the same background datasets and methods are used, the factors are consistent with those obtained from Ecoinvent and WFLDB, meaning that companies can combine activity data on farm-level practices obtained from suppliers with regional or global average data. When the user selects a crop and region, ALCIG automatically self-populates with the regional average data on crop production practices and background data (e.g. emissions embodied in fertilizers) used by WFLDB and Ecoinvent. The user can then overwrite the data on crop production practices with supplier-specific information. As with Cool Farm Tool, ALCIG has comprehensive coverage of emission sources and sinks, but is limited to crop products. The output from ALCIG includes life cycle inventory data for the given product at the unit process level (e.g. $N_2O$ emissions per 1 kg output fresh crop product, unpackaged, at farm exit), which can be imported into LCA software.

- **GLEAM** (FAO, 2013) is a spatially explicit life cycle assessment model for the livestock sector. It covers 11 livestock commodities at global scale: meat and milk from cattle, sheep, goats and buffalo; meat from pigs; and meat and eggs from chickens. The original GLEAM model requires substantial expertise and is not available to the public. However, an Excel-based version called GLEAM-i (GLEAM-interactive) is more user-friendly and can be downloaded online. Upon the user choosing a region and country for the simulation, GLEAM-i automatically populates with national default data on animal population, herd parameters, feed rations, manure management, and LUC. The user can change any of these data to run a custom simulation or to compare a "with project" scenario against a baseline. The tool then calculates production of livestock commodities and GHG emissions arising from each stage of production. Source and sink categories include feed production, fertilizer and pesticide use in feed production, on-farm energy and fuel use, enteric fermentation, manure management, LUC associated with expansion of feed crops, processing, packaging, storage, and transportation. GLEAM-i is intended primarily for national-level simulations to test the effect of livestock policies or projects, but can be used at a sub-national scale by altering default data parameters. In the context of estimating scope 3 emissions within agricultural value chains, GLEAM-i could be used to calculate emission factors (GHG emissions per unit production) specific to production conditions within a given value chain.

In addition to these agricultural GHG calculators with global coverage, approximately 20 other calculators exist that are specific to the United States, New Zealand, Australia, the United Kingdom, or other European countries. Further information on those country-specific calculators can be found in Colomb *et al*. (2013) and Denef *et al*. (2012). Where such country-specific calculators are available, they often reduce data input requirements for the user by pre-populating the software with data available from national governments. For example, the Fieldprint* Platform and Comet Farm both automatically integrate spatially explicit data on climate and soils from the U.S. Department of Agriculture (USDA). Such data sets are not available globally and therefore must be entered manually in most calculators with global coverage.

The remaining two GHG calculators with global coverage that are most likely to be useful to companies for estimating emissions from agriculture and LUC are specific to LUC: BigChain Tool and Direct Land Use Change Assessment Tool.

- **The BigChain Tool** (South Pole Group, 2017) identifies deforestation risks associated with the sourcing of raw materials. Using company-specific information on the commodity in question, amount sourced, and region, the tool generates information on extent of deforestation and associated scope 3 emissions attributable to the sourcing of that commodity. Companies are required to input the commodity, sourcing region (mill-level knowledge is helpful), and quantity sourced, for one or several commodities. The BigChainTool takes these company-supplied data and conducts Geographic Information Systems (GIS) analysis of likely deforestation impacts, combining the location of produced crops of interest in the determined region with the observed deforestation in the same geography. South Pole processes the raw information and produces an analysis of hectares of deforestation and resulting emissions (using IPCC Tier 1 methodologies) for the relevant commodities and geographies.
- **The Direct Land Use Change Assessment Tool** (Blonk Consultants, 2014) estimates LUC and resulting emissions associated with commodity crop production using national average data from FAO and other sources. The tool is not available for public use; Blonk Consultants use the tool in their consulting engagements with companies. The tool is recommended by the LUC Guidance and approved for use with the GHG Protocol. It is especially intended for situations in which little primary data are available beyond crop type and, optionally, the country of origin. The tool provides three basic functionalities, based on the amount of data available for input:
  1. When the source country of a product is known, but the previous land use is not known, the tool estimates LUC based on a number of reference

scenarios for previous land use, combined with data from relative crop land expansions based on FAOSTAT, a database of agriculture and land use statistics maintained by the UN Food and Agriculture Organization.

2. When neither the source country nor the associated LUC are known, GHG emissions arising from LUC are calculated as the weighted average of the average LUC emissions of that commodity in the countries in which it is grown, based on FAO statistics.
3. When the country of production and previous land use are known, emissions from LUC are calculated according to IPCC Tier 1 methodologies, with the carbon stock change linearly amortized over a period of 20 years.

The Direct Land Use Change Assessment Tool differs from the BigChain Tool in that it can assess types of LUC beyond just deforestation (e.g. it can estimate emissions from the conversion of grassland to cropland). However, neither the BigChain Tool nor the Direct Land Use Change Assessment Tool are able to estimate emissions from indirect LUC. The LUC Guidance (Quantis, 2018) provides guidelines on methods for estimating indirect LUC.

The **BigChain Tool** and the **Direct Land Use Change Assessment Tool** rely on remotely sensed data (data from satellite- or aircraft-based sensor technologies) to detect LUC. Several other tools and platforms provide this functionality as well, but stop short of calculating associated GHG emissions. For example, **Global Forest Watch** (World Resources Institute, 2014) provides high-resolution data on forest cover and tree cover loss in an interactive web-based tool, as well as weekly alerts on areas of likely deforestation, allowing companies to identify potential deforestation risks as they happen. Global Forest Watch allows users to analyze tree cover, tree cover loss, aboveground biomass density, and other metrics within a geographic area of interest and assess deforestation risk within a geographically explicit sourcing area. All of the data on Global Forest Watch are freely available. The main difference between Global Forest Watch and resources such as the BigChain Tool and the Direct Land Use Change Assessment Tool is that to make use of Global Forest Watch to monitor LUC in supply chains, a company must know the specific geographic area where the commodity is produced. The other tools can make use of secondary data (e.g. deforestation in areas where the commodity is *usually* grown) to estimate LUC associated with the commodity, although they can also produce company-specific estimates if the area of production is known. Global Forest Watch also does not calculate emissions associated with deforestation, although information on the area of deforestation obtained from Global Forest Watch could be separately entered into a distinct GHG calculator such as Ex-ACT or used with IPCC methodologies to estimate emissions.

### BOX 2: GHG EMISSIONS DISCLOSURE AND CDP

*CDP runs a comprehensive collection of self-reported environmental data, requesting information on GHG emissions from the world's largest companies. CDP's primary areas of focus include climate, water, and forests. CDP's climate questionnaire in particular provides a platform for companies to report on disclosure, awareness, management, and leadership regarding climate change action. Through CDP's climate questionnaire, companies across all supply chain segments can disclose on Scope 1, 2, and 3 emissions. Companies can also disclose on distinct categories of Scope 3 emissions, including emissions from purchased goods and services such as raw agricultural products.*

*In collaboration with the sustainability consulting group Quantis, CDP is currently looking into opportunities to best assist companies to account for, and report on, GHG emissions from LUC. They are in the processes of assessing potential changes to their Climate Change and Forests questionnaires that can better capture and track how companies are addressing and managing GHG emissions from LUC in their direct operations and value chains.*

## TABLE 1. A COMPARISON OF SELECT GHG EMISSIONS CALCULATION TOOLS

| | DIRECT LAND USE CHANGE ASSESSMENT TOOL (BLONK CONSULTANTS) | BIGCHAIN TOOL (SOUTH POLE GROUP) | AGRICULTURAL LIFE CYCLE INVENTORY GENERATOR TOOL (QUANTIS) | COOL FARM TOOL (SUSTAINABLE FOOD LAB) | GLEAM-I (GLOBAL LIVESTOCK ENVIRONMENTAL ASSESSMENT MODEL – INTERACTIVE) (FAO) |
|---|---|---|---|---|---|
| **Resource Overview** | Estimates LUC and resulting emissions associated with commodity crop production. Particularly useful as a first-pass analysis when little primary data is available beyond the type of crop and, optionally, the country of origin. | Rapid forest-risk quantification tool that quantifies GHG emissions due to deforestation as a result of commodity production and expansion associated with corporate supply chains. | Generates custom emission factors by combining company-specific farm management data with background data sets from ecoinvent and WFLDB; emission factors can then be imported into Life Cycle Analysis software for further analysis. | Calculates product- and farm-level GHG emissions and carbon stock changes (changes in soil and biomass carbon) resulting from the production of a crop or livestock product from a given farm in a given year | Spatially explicit life cycle assessment model for the livestock sector; calculates GHG emissions from livestock supply chains based on input metrics regarding herd, feed, and manure management |
| **Targeted End Users** | Companies interested in obtaining general information about forest risks associated with a particular commodity or estimating GHG emissions from LUC associated with sourcing a commodity from a certain country | Companies with data on volume and sourcing location of specific commodities, and buyers or traders interested in opportunities to mitigate deforestation-related risk across their known supply chains | Expert LCA practitioners who want to use custom emission factors in LCA programs; third-party organizations with direct engagements with producers and farmers | Commodity growers/producers | Primarily intended for national policy makers but could be used by LCA practitioners or companies to calculate emission factors specific to production conditions within a given value chain |
| **Databases/ Protocols Used** | PAS 2050 – 1 methodology (an extension of IPCC); Tier 1 emission factors from IPCC (2006); LUC data from FAO | Forest cover change data from GFW; commodity production data from Earthstat; attribution of deforestation using LUC data from FAO; IPCC (2006) Tier 1 methodology for GHG calculations | IPCC (2006) methodologies; uses the same methods and background datasets used to generate emission factors in LCA databases such as Ecoinvent and the WFLDB | Applies emission factors primarily based on IPCC (2006) Tier 1 methodology | Total animal numbers from FAO; spatial distribution of animals and production systems from Gridded Livestock of the World (Robinson et al., 2014); calculates GHG emissions using IPCC (2006) Tier 2 methodologies. |
| **Input Data Required** | Type of commodity crop sourced (required); country of origin (optional); previous land use at sourcing location (optional) | Amount (volume) and sourcing region of commodities of interest; more specific sourcing information (e.g. mill) is optional | Agricultural management data; database accounts for up to 200 different input parameters | Agricultural management data | Data on herd size and structure, feed rations, manure management, and land use change (optional) |
| **Summary of Methodology** | When only the commodity crop is known (but not the source country or previous land use), LUC emissions are calculated as the weighted average of the average LUC emissions of that commodity in the countries in which it is grown, based on FAO statistics. If the source country is known, the tool estimates land use changes based on a number of reference scenarios for previous land use, combined with data from relative crop land expansions from FAO. Calculation of GHGs uses IPCC Tier 1 methodology. | Combines company-specific sourcing data with publicly available datasets (e.g. GFW, WRI) to produce a geospatially explicit, graphic analysis of observed deforestation located within the same geospatial boundary as a commodity's sourcing footprint. Assumes 100% of observed deforestation is due to agricultural expansion. Calculation of GHGs uses IPCC Tier 1 methodology. | Automatically self-populates with regional average data on crop production practices and background data (e.g. emissions embodied in fertilizers) used by WFLDB and ecoinvent. The user can then over-write the data on crop production practices with company-specific information obtained from pilot projects or the like. Includes emissions associated with direct land use change. | Applies emission factors and empirical models to activity data inputted by the user to calculate net GHG emissions associated with farm-level activities. Includes emissions and carbon sequestration associated with on-farm changes in land use. | Runs in a Geographic Information System (GIS) environment to provide spatially disaggregated estimates on GHG emissions and commodity production by production system. Upon choosing a region and country for the simulation, automatically populates with national default data and applies IPCC (2006) Tier 2 methodology to calculate livestock production metrics (e.g. meat, milk, eggs) and associated emissions estimates ($CO_2e$) disaggregated by species and emissions source. User can change input data to run custom scenarios. |
| **Geographic Scope of Tool** | Depends on locations of commodity production; may be single or multi-country | Local/regional (user provides location of interest) | Product-level | Farm- and product-level | National- and product-level can be used subnationally or locally by altering input parameters |
| **Tool Accessibility** | Not in the public domain. Licenses available for purchase. | Not in the public domain. South Pole Group uses the tool in their consulting engagements. | Not in the public domain. Can use the Tool a limited number of times for free following registration, with licenses available for purchase. | Free to use by growers. Supply chain and retail businesses must pay to become Cool Farm Alliance members to use the Tool directly, or via their supply chains. | Publicly available |

*A summary table of 5 GHG calculators likely to be useful to companies when estimating emissions from agriculture and LUC.*

# Gaps in GHG calculation tools

While GHG calculation tools outlined in this report can certainly serve as helpful resources for companies looking to better manage agricultural commodity supply chain emissions, the state of GHG calculation tools is still in need of development when it comes to measuring:

- **Indirect land-use change.** In the context of agricultural commodities, indirect land use change refers to land conversion to agriculture (and associated emissions) in response to increased global demand for agricultural products. It is difficult to assess and currently lacks a well-established accounting methodology, although is becoming increasingly recognized and promoted as an important component of GHG emissions accounting efforts for agricultural supply chains.
- **Emissions from land degradation.** Tools outlined in this report that assess emissions from land use change largely account for full conversion of one land use to another (e.g. grassland to cropland). However, land degradation—involving a decline in land quality as a result of degradation or loss of soil, water, or vegetative cover—is also relevant in LUC emissions calculations, but difficult to quantify, and not yet widely incorporated into these tools.
- **Soil carbon.** Soil carbon is technically difficult to measure, but accounting for soil carbon is a critical component of carbon accounting in agricultural systems. Quantifying soil carbon can also be an important factor in broader climate change mitigation strategies, since soil carbon management is one of the most cost-effective climate change mitigation options today.

# Recommendations

## FOR COMPANIES JUST BEGINNING TO DISCLOSE GHG EMISSIONS AND/OR WITH LITTLE ACCESS TO GEOGRAPHICALLY EXPLICIT, SUPPLY CHAIN-SPECIFIC GROWING DATA:

Many companies use product-level emission factors from LCA databases to initially build a GHG inventory that includes emissions from agriculture because the corresponding activity data are much easier to obtain. A company need only know the quantity of an agricultural product used in its operations (e.g. kilograms of bananas) in order to calculate the associated emissions. Such factors are sometimes referred to as *secondary data*—data that represent international or regional averages and are not specific to a company's own supply chain. The drawback to this method is that it does not reflect the specific production conditions within the company's supply chain, so the inventory will not capture changes in emissions resulting from improvements in agricultural production or reductions in LUC.

## FOR COMPANIES THAT HAVE ACTIVITY DATA SPECIFIC TO ITS OWN OPERATIONS (E.G. UPSTREAM PRODUCERS/GROWERS, OR VERTICALLY INTEGRATED FOOD COMPANIES):

Activity data specific to a company's own operations—called *primary data*—can be used in conjunction with emission factors for agricultural management activities to calculate supply chain emissions. In such calculations, companies would use the IPCC Emissions Factor Database to calculate emissions. Companies that directly control agricultural production operations, such as primary producers, would likely do this as part of the company's scope 1 emissions inventories.

## FOR COMPANIES FURTHER DOWNSTREAM IN THE SUPPLY CHAIN, SUCH AS PACKAGED FOOD MANUFACTURERS AND RETAILERS:

Collecting primary data not only requires full traceability of raw materials, but also primary data from potentially thousands of individual producers. Some companies rely on the GHG inventory reports of their suppliers in order to construct their own scope 3 emissions inventory. If this is not possible, companies may choose to work with a smaller selection of suppliers (prioritizing based on suppliers in categories with the largest estimated emissions impact for example) to develop product-level emission factors that reflect the average production processes in their supply chain. Some companies use product certifications such as USDA Organic or Rainforest Alliance as a proxy for emissions levels associated with a particular product, although this is only useful insofar as the certification reflects the drivers of emissions specifically associated with the product. Similarly, companies may also develop "typologies" of the products they source according to the method of production in certain geographies or among certain producers. For example, if a company sources wheat from a number of producers in the midwestern United States that all use similar production practices, it could use a GHG calculator to estimate the emissions associated with wheat purchased from those producers, without collecting data from each individual producer.

Overall, GHG calculators provide a means of estimating product-level emission factors using primary data. Nearly all agricultural GHG calculators are based on IPCC (2006) methodologies and will provide similar results when used with identical activity data. The difference between them is the level of activity data input required and level of customization allowed by the user. In general, the more specific the activity data, the more accurate the tool result will be. However, this is true only to the extent that activity data are accurate. If activity data are of low quality (i.e. rough estimations), users may be better off using default data provided by the tool (if available) or choosing a tool with lower data requirements. Tools with country-specific calculators often reduce data input requirements for the user by pre-populating the tool with data available from national governments.

When choosing a calculator, companies should consider a range of factors (WRI and WBCSD, 2014):

- Is the tool comprehensive in terms of its coverage of emission sources, GHGs and management activities (particularly those most relevant to the agricultural product under consideration)?
- What input data are required and will suppliers be able to provide these data?
- Is the tool transparent about its methodology, including limitations and assumptions?
- Is the tool geographically representative? Is it tailored to the region/area of interest?
- Is the methodology used by the tool advanced enough to provide sufficient accuracy? (Note that the more advanced the methodology, the more accurate the results are likely to be, but the higher the data input requirements as well.)
- Does the tool provide estimates of uncertainty?

Companies and suppliers may also choose to use the IPCC (2006) guidelines directly in order to calculate emissions from agricultural production. In doing so, they should ensure to account for all major emission sources associated with the production of a given product. One advantage of using IPCC guidelines directly is that it allows the use of tier 2 calculation methodologies, which are not available in many GHG calculators (such as Cool Farm Tool).

# Potential questions for investors to ask companies about Scope 3 emissions estimation

**Several questions can help guide investor engagements with companies tracking scope 3 emissions from agriculture and agriculturally-driven LUC.**

## DOES THE COMPANY USE A RECOGNIZED METHODOLOGY FOR ITS GHG INVENTORY RELATED TO SCOPE 3 EMISSIONS?

The suite of methodologies from the GHG Protocol (Corporate Accounting and Reporting Standard, Corporate Value Chain (Scope 3) Standard, Product Life Cycle Accounting and Reporting Standard are the most widely used among companies reporting to CDP and provide sound guidance on how to prioritize emission sources, set boundaries, choose base years, account for changes in emissions over time and generally formulate a GHG inventory. However, since these methodologies do not prescribe GHG calculation methods, reference to these methodologies does not guarantee that the calculation methodologies are sound.

## TO CONSTRUCT THEIR GHG INVENTORY, DOES THE COMPANY USE GLOBALLY OR REGIONALLY REPRESENTATIVE AVERAGES OR DOES THE COMPANY COLLECT DATA FROM THEIR SUPPLIERS?

**For companies just beginning to disclose GHG emissions and/or with little access to geographically explicit, supply chain-specific growing data:** Companies may first construct a scope 3 GHG inventory using secondary data: global or regional average product-level emission factors from LCA databases for the products in their supply chains. The drawback to this approach is that it does not reflect the specific production conditions within the company's supply chain, so it will not capture GHG reductions due to improvements in agricultural management.

**For companies further along in their disclosure journey and/or with greater access to geographically explicit, supply chain-specific growing data:** Companies should work with suppliers to collect primary data (supplier-specific product emission factors or activity data on supplier-specific agricultural management practices) based on prioritized emission sources within its supply chain. This will allow companies to account for changes in agricultural practice that have the largest impact on emissions (such as differences in animal productivity for livestock products, or efficiency of fertilizer use for crop products).

**Specific guidance for processed food manufacturers and retailers:** It may be useful to first identify the commodities in the supply chain with the largest GHG footprints, then focus on specific sources of GHGs associated with those commodities. Identifying the largest source of GHGs associated with a commodity—such as deforestation or fertilizer use—will help the company prioritize collection of activity data. GHG calculators may be used to calculate emissions using company-specific activity data. Use of country-specific calculators, where available, can reduce data collection needs by pre-populating the calculator with climate and soil data (for example).

## DOES THE COMPANY INCLUDE GHG EMISSIONS FROM LUC IN THEIR SCOPE 3 INVENTORY?

If LUC results in carbon stock reductions, companies should include GHG emissions from LUC in their scope 3 emissions inventory. To first estimate LUC for commodities with high deforestation risks (such as palm oil, soy, and livestock products), companies may use tools such as the BigChainTool or the Direct Land Use Change Assessment Tool, which can utilize global or regional average data to estimate potential deforestation and resulting emissions. Companies with significant exposure to deforestation risk should collect more accurate information on source locations in order to verify the absence of deforestation in their supply chains. Such information will improve the accuracy of estimates provided by The BigChainTool or The Direct Land Use Change Assessment Tool.

Although relatively new, the Land Use Change Guidance synthesizes and builds upon recognized existing approaches and the recommendations are comprehensive. It may become the widely-used benchmark for LUC accounting in supply chains.

## DOES THE COMPANY ACCOUNT SEPARATELY FOR CARBON SEQUESTRATION IN AGRICULTURAL SOILS AND REFORESTATION?

The climate change mitigation potential of carbon sequestration in agricultural soils and trees is large. However, estimates of potential sequestration in soils (in particular) are subject to high uncertainty, and such sequestration is reversible if the carbon-enhancing practice ceases. Estimates of mitigation potential due to soil carbon gains should be interpreted with caution. If carbon sequestration is reported as part of a company's scope 3 inventory, it should be reported separately from GHGs emitted from agricultural production.

## DOES THE COMPANY HAVE A PLAN FOR CONSISTENTLY TRACKING EMISSIONS WHEN METHODOLOGIES IMPROVE?

Per the GHG Protocol Corporate Standard, companies should recalculate their base year emissions when improving calculation methodologies or undergoing structural changes (such as acquisitions), in order to ensure consistent emissions tracking. As companies improve their monitoring of scope 3 emissions, it is important to establish guidelines for aggregating data at different levels of granularity and re-calculating baselines, to ensure consistency across supply chains and over time. Estimates of emissions calculated using different methodologies may lead to a false perception of mitigation—or increased emissions—where none exists. Tools such as the Agricultural Life Cycle Inventory Generator may be useful for companies in combining data obtained from their own suppliers with emission factors from LCA databases.

# Further reading

## SELECTION OF GHG CALCULATORS

Denef, K., Paustian, K., Archibeque, S., Biggar, S., Pape, D., 2012. Report of Greenhouse Gas Accounting Tools for Agriculture and Forestry Sectors. Interim report to USDA under Contract No. GS-23F-8182H.

Colomb, V., Bernoux, M., Bockel, L., Chotte, J.-L., Martin, S., Martin-Phipps, C., Mousset, J., Tinlot, M., Touchemoulin, O., 2012. Review of GHG calculators in agriculture and forestry sectors. Food and Agriculture Organization of the United Nations (FAO), Rome.

Colomb, V., Touchemoulin, O., Bockel, L., Chotte, J.-L., Martin, S., Tinlot, M., Bernoux, M., 2013. Selection of appropriate calculators for landscape-scale greenhouse gas assessment for agriculture and forestry. Environ. Res. Lett. 8, 15029.

Keller, E., Chin, M., Chorkulak, V., Clift, R., Faber, Y., Lee, J., King, H., Milà i Canals, L., Stabile, M., Stickler, C., Viart, N., 2014. Footprinting farms: a comparison of three GHG calculators. Greenh. Gas Meas. Manag. 1–34.

Seebauer, M., 2014. Whole farm quantification of GHG emissions within smallholder farms in developing countries. Environ. Res. Lett. 9, 35006.

## METHODOLOGIES AND TOOLS REFERENCED IN THE REPORT

**IPCC reporting guidelines for agriculture, forestry and other land use**
http://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html

**IPCC Emission Factor Database**
https://www.ipcc-nggip.iges.or.jp/EFDB/main.php

**GHG Protocol methodologies**
www.ghgprotocol.org

**Land Use Change Guidance**
https://quantis-intl.com/lucguidance/

**Ex-Ante Carbon Balance Tool**
http://www.fao.org/tc/exact/ex-act-home/en/

**Cool Farm Tool**
https://coolfarmtool.org/

**Agricultural Life Cycle Inventory Generator**
https://alcig.quantis-software.com/
https://alcig.quantis-software.com/ALCIG_methodology.pdf?v=1.3.0-SNAPSHOT

**GLEAM-i**
http://www.fao.org/gleam/en/

### World Food Life Cycle Assessment Database

https://quantis-intl.com/tools/databases/wfldb-food/

Nemecek T., Bengoa X., Lansche J., Mouron P., Riedener E., Rossi V. & Humbert S. (2015) Methodological Guidelines for the Life Cycle Inventory of Agricultural Products. Version 3.0, July 2015. World Food LCA Database (WFLDB). Quantis and Agroscope, Lausanne and Zurich, Switzerland. https://quantis-intl.com/wp-content/uploads/2017/02/wfldb_methodologicalguidelines_v3.0.pdf

### Agri-footprint

http://www.agri-footprint.com/users/

Durlinger, B., Koukouna, E., Broekema, R., Paasen, M. van, Jasper Scholten, 2017. Agri-footprint 4.0. Blonk Consultants, Gouda, Netherlands.

### Global Forest Watch

http://commodities.globalforestwatch.org/

### BigChain Tool

https://openforests.com/project/bigchain-tool-south-pole-group-worldwide/
https://www.southpole.com/public/marketing/SPG_BigChainTool.pdf
http://www.earthstat.org/

### Direct Land Use Change Assessment Tool

http://www.blonkconsultants.nl/portfolio-item/direct-land-use-change-assessment-tool
http://www.blonkconsultants.nl/wp-content/uploads/2017/10/Update-description-Direct-Land-Use-Change-Assessment-Tool-Version-2017.2.pdf

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Hansen, M.C., Krylov, A., Tyukavina, A., Potapov, P. V, Turubanova, S., Zutta, B., Ifo, S., Margono, B., Stolle, F., Moore, R., 2016. Humid tropical forest disturbance alerts using Landsat data. Environ. Res. Lett. 11, 34008.

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WRI, WBCSD, 2011. The GHG Protocol Product Life Cycle Accounting and Reporting Standard. World Resources Institute and World Business Council for Sustainable Development, Washington D.C.

WRI, WBCSD, 2014. GHG Protocol Agricultural Guidance. World Resources Institute and World Business Council for Sustainable Development, Washington D.C.