# Accounting Guidelines for Impacts on Land-use and the Environment (AGILE)

DRAFT FOR PUBLIC CONSULTATION (APRIL 2025)

STEP

3

MEASURE, SET
& DISCLOSE

LAND

SCIENCE BASED TARGETS NETWORK
GLOBAL COMMONS ALLIANCE

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# Acknowledgments

This guidance was developed by the Science Based Targets Network's Land Hub as a contribution to the Science Based Targets Network (SBTN), which aims to transform economic systems and protect the global commons—our air, water, land, biodiversity, and ocean. SBTN unites experts from more than 80 non-governmental organizations (NGOs), business associations, and consultancies to collectively define what is necessary to do "enough" to stay within Earth's limits and meet society's needs.

In partnership with SBTN, the Land Hub is a collaboration between World Wildlife Fund (Craig Beatty co-lead, Cristóbal Loyola), Conservation International (Alex Zvoleff co-lead, Jordan Rogan), The Nature Conservancy (Lyndsey Dowell), World Resources Institute (Elise Mazur), and the Food and Land Use Coalition/Systemiq (Scarlett Benson, Marco Daldoss Pirri). The objective of the SBTN Land Hub is to develop and promote a methodology that will allow companies to set, track, and measure progress on quantifiable targets that are representative of the progress required in land systems to sustain nature and people. The Land Hub is responsible for developing the technical content of these targets for inclusion as part of SBTN's multi-stakeholder, multi-year initiative to provide companies with comprehensive science-based targets for nature.

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2) The scope of these guidelines is confined to SBTN Step 3: Measure, Set, & Disclose of the five-step SBTN Framework. Step 4: Act and Step 5: Track will be addressed in later versions of SBTN's guidance.
3) These are guidelines to direct voluntary corporate actions in line with company commitments to science-based targets for nature and is not a regulatory framework.
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# Glossary

- **AFi -** Accountability Framework initiative.
- **Allocation -** Assignment of a given company's portion of effort towards issue/impact mitigation
- **AR3T -** Action Framework is named AR3T because it covers actions to avoid future impacts, reduce current impacts, regenerate and restore ecosystems, and transform the systems in which companies are embedded.
- **Avoid -** Prevent impact happening in the first place, eliminate impact entirely.
- **Bare land -** Areas with exposed rock, soil, or sand with less than 10% vegetated cover.
- **Baseline -** Value of impacts (on nature) or state (of nature) against which an actor's targets are assessed, in a particular previous year.
- **Biodiversity -** The variability among living organisms from all sources, including, inter alia, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems (Convention on Biological Diversity (CBD) 1992, Article 2).
- **CBD -** Convention on Biological Diversity.
- **Characterization factor -** Factor derived from a characterization model which is applied to convert an assigned life cycle inventory analysis result to the common unit of the category indicator (ISO 14044).
- **Composition of an ecosystem -** This refers to the biotic constitution of ecosystems—the pattern of the makeup of species communities and the interactions between them. It refers to the identity and variety of life.
- **Consolidation approaches:** There are three consolidation approaches for a company to define its organizational boundaries; operational control, financial control and equity share ((draft) GHG Protocol LSRG, 2022).
- **Conversion -** A change of a natural ecosystem to another land use or a profound change in a natural ecosystem's species composition, structure, or function. Deforestation is one form of conversion (conversion of natural forests). Conversion includes severe degradation or the introduction of management practices that results in substantial and sustained change in the ecosystem's former species composition, structure, or function. Change to natural ecosystems that meets this definition is considered to be conversion regardless of whether or not it is legal.
- **Cutoff dates –** The cutoff date provides a baseline for the target. After this date, any conversion of natural ecosystems on a given production unit renders the materials produced on that production unit non-compliant with an SBTN No Conversion Target.
- **Degradation -** Changes within a natural ecosystem that significantly and negatively affect its species composition, structure, and/or function and reduce the ecosystem's capacity to supply products, support biodiversity, and/or deliver ecosystem services. Degradation may be considered conversion if it is large-scale and progressive or enduring; alters ecosystem composition, structure, and function to the extent that regeneration to a previous state is unlikely; or leads to a change in land use (e.g., to agriculture or other use that is not a natural forest or other natural ecosystem) (AFi, 2024).
- **Direct operations -** All activities and sites (e.g., buildings, farms, mines, retail stores) over which the enterprise has operational or financial control. This includes majority-owned subsidiaries.
- **Downstream -** This covers all activities that are linked to the sale of products and services produced by the company setting targets. This includes the use and re-use of the product and its end of life to include recovery, recycling, and final disposal.

- **DPSIR Causal Framework -** Describes causal relationships in social-ecological systems between driver (D), pressure (P), state (S), impact (I), and response (R) indicators.
- **Ecological/habitat connectivity -** The degree to which the landscape facilitates the movement of organisms (animals, plant reproductive structures, pollen, pollinators, spores, etc.) and other environmentally important resources (e.g., nutrients and moisture) between similar habitats. Connectivity is hampered by fragmentation (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES))
- **Ecosystem -** A dynamic complex of plant, animal, and microorganism communities and the non-living environment interacting as a functional unit. Within this definition, the term "unit" relies on the identification of a distinct function as well as a "dynamic" grouping of biotic and abiotic factors. When using an ecosystem approach to conservation, the CBD suggests an ecosystem can refer to any functioning unit, regardless of scale. Thus, the term is not necessarily synonymous with "biome" or "ecological zone" and is better determined by the problem that is being addressed.
- **Ecosystem condition -** The quality of an ecosystem measured by its abiotic and biotic characteristics. Condition is assessed by an ecosystem's composition, structure, and function, which, in turn, underpins the ecological integrity of the ecosystem and supports its capacity to supply ecosystem services on an ongoing basis (UN System of Environmental Economic Accounting (SEEA), 2021—Ecosystem Accounting: Final Draft).
- **Ecosystem function -** The flow of energy and materials through the biotic and abiotic components of an ecosystem. This includes many processes such as biomass production, trophic transfer through plants and animals, nutrient cycling, water dynamics, and heat transfer (IPBES).
- **Ecosystem integrity -** encompasses the full complexity of an ecosystem, including the physical, biological, and functional components, together with their interactions, and is measured against a "natural" (i.e., current potential) reference level. It is the extent to which the composition, structure, and function of an ecosystem fall within their natural range of variation.
- **Elementary flow -** Material or energy entering the system being studied, sourced from the environment without previous human transformation (e.g. timber, water, iron, coal, crude oil), or material or energy leaving the system being studied and released into the environment without subsequent human transformation (e.g. CO2, noise emissions, wastes discarded in nature) (ISO 14044).
- **FLAG -** The Forest, Land and Agriculture (FLAG) Guidance of the Science Based Targets initiative.
- **Forests -** Land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10%, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or other land use (Food and Agriculture Organization (FAO)).
- **Free, prior and informed consent -** Free, prior, and informed consent (FPIC) is a specific right that pertains to Indigenous Peoples and is recognized in the United Nations Declaration on the Rights of Indigenous Peoples. FPIC is a mechanism that safeguards the individual and collective rights of Indigenous and tribal peoples, including their land and resource rights and their right to self-determination. The minimum conditions that are required to secure consent include that it is "free" from all forms of coercion, undue influence, or pressure, that it is provided "prior" to a decision or action being taken that affects individual and collective human rights, and that it is offered on the basis that affected peoples are "informed" of their rights and the impacts of decisions or actions on those rights. FPIC is considered to be an ongoing process of negotiation, subject to an initial consent. To obtain FPIC, "consent" must be secured through an agreed process of good faith consultation and cooperation with Indigenous and tribal peoples through their own

representative institutions. The process should be grounded in a recognition that the Indigenous or tribal peoples are customary landowners. FPIC is not only a question of process, but also of outcome, and is obtained when terms are fully respectful of land, resource, and other implicated rights (FAO (2016): Free Prior and Informed Consent - An Indigenous Peoples' Right and a good practice for local communities).

- **GBF -** Final Kunming–Montreal Global Biodiversity Framework.
- **GHGP -** Greenhouse Gas Protocol.
- **Goal -** In global (e.g. UN) sustainability framings, a high-level statement of ambition, including a time frame. Example: By 2030, ensure healthy lives and promote wellbeing for all at all ages (Sustainable Development Goal (SDG) 3).
- **High-impact commodities -** Raw and value-added materials used in economic activities that are known to have material links to the key drivers of biodiversity loss, resource depletion, and ecosystem degradation. Activities associated with high-impact commodities include: extraction of these commodities (e.g., mining, farming), clearing of lands for extraction, processing of commodities (into refined or value-added forms), manufacturing commodities into complex products (with additional inputs), distribution of commodities, and the procurement of commodities (in their raw, value-added, or final form). For more information, please see SBTN Step 1 Guidance.
- **Impacts -** These can be positive or negative contributions of a company or other actor toward the state of nature, including pollution of air, water, or soil; fragmentation or disruption of ecosystems and habitats for nonhuman species; and alteration of ecosystem processes.
- **Impact category -** Environmental issue of concern.
- **Impacts on nature -** A change in the state of nature, which may result in changes to the capacity of nature to provide value to business and society and/or instrumental, relational, and intrinsic value (Taskforce on Nature-Related Financial Disclosures (TNFD)).
- **Indicator -** A measurable entity related to a specific information need, such as the state of nature, change in a pressure, progress toward a target, or association between two or more variables. Example: Red List Index (SDG Target 15.5; Aichi Target 12).
- **Land cover -** The observed physical and biological cover of Earth's land.
- **Land footprint/land occupation -** A company's land footprint, known in life cycle assessment terms as "land occupation," is defined for these guidelines as the amount of land required per year to produce the products produced or sourced by a company, and it is reported in hectares per year. For crops, land occupation is also referred to as "harvested area" in the FAO's data portal FAOSTAT. Importantly, "land footprint" or "land occupation" for the purpose of these guidelines refers to "working lands" used to produce products in corporate supply chains—not necessarily all land owned or controlled by companies.
- **Landscape -** A socio-ecological system that consists of natural and/or human-modified ecosystems, and which is influenced by distinct ecological, historical, economic, and socio-cultural processes and activities. For the purpose of this guidance, the landscape is the area where a landscape approach is being implemented. In ideal cases, the landscape will have been defined through a broad stakeholder-led process in which a company may begin its participation. This may not always be the case for areas that are relevant for companies. In these cases, a more prescriptive approach to landscape identification may be required. Here it may be possible to utilize water basin boundaries identified through the SBTN Freshwater target methodology or through SBTN's Step 2: Interpret & Prioritize process.
- **Landscape approach -** Collaboration of stakeholders within a defined natural or social geography, such as watershed, biome, or company sourcing area. This approach seeks to reconcile competing social,

economic, and environmental goals through "integrated landscape management"—a multi-stakeholder approach that builds consensus across different sectors with or without government entities.

- **Land use -** All the arrangements, activities, and inputs undertaken in a certain land-cover type (a set of human actions) or the social and economic purposes for which land is managed (e.g., grazing, timber extraction, conservation).
- **Land use change -** Land uses can change over time due to both natural and anthropogenic causes. Such changes can be represented by land use change categories (e.g., forest land converted to cropland). Where the land use category remains the same but the land use subcategory changes, for example conversion from a primary forest (natural forest) to a plantation forest (planted forest), this should be accounted for as land use change.
- **Life cycle assessment -** Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle (ISO 14044)
- **Life cycle impact assessment -** Phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product (ISO 14044).
- **Measurement -** The process of collecting data for baseline setting, monitoring, and reporting.
- **Monitoring -** Tracking progress toward targets.
- **Natural ecosystem -** An ecosystem that substantially resembles—in terms of species composition, structure, and ecological function—what would be found in a given area in the absence of major human impacts. This includes human-managed ecosystems where much of the natural species composition, structure, and ecological function are present. Natural ecosystems include:
    - largely "pristine" natural ecosystems that have not been subject to major human impacts in recent history;
    - regenerated natural ecosystems that were subject to major impacts in the past (for instance by agriculture, livestock raising, tree plantations, or intensive logging) but where the main causes of impact have ceased or greatly diminished, and the ecosystem has attained species composition, structure, and ecological function similar to prior or other contemporary natural ecosystems;
    - managed natural ecosystems (including many ecosystems that could be referred to as "seminatural") where much of the ecosystem's composition, structure, and ecological function are present—this includes managed natural forests as well as native grasslands or rangelands that are, or have historically been, grazed by livestock;
    - natural ecosystems that have been partially degraded by anthropogenic or natural causes (e.g., harvesting, fire, climate change, invasive species, or others) but where the land has not been converted to another use and where much of the ecosystem's composition, structure, and ecological function remain present or are expected to regenerate naturally or by management for ecological restoration (AFi, 2024).
- **Nature** - The diversity of living organisms, including people, and their interactions with each other and their environment. This perspective emphasizes the deep connection between ecological and human well-being.
- **Natural forests -** Natural forests possess many or most of the characteristics of a forest native to the given site, including species composition, structure, and ecological function.
- **Nature's contributions to people -** (NCPs—also known as "ecosystem services") All the beneficial and detrimental contributions that we obtain from and with nature (IPBES Global Assessment: 26). In general, NCPs are categorized as material NCPs (e.g., wild-harvested foods), regulating NCPs that govern

biophysical processes (e.g., carbon storage, flood regulation), and nonmaterial NCPs that provide cultural services. In total, the different categories of NCP recognized by IPBES are: habitat creation and maintenance (NCP 1); pollination and dispersal of seeds and other propagules (NCP 2); regulation of air quality (NCP 3); regulation of climate (NCP 4); regulation of ocean acidification (NCP 5); regulation of freshwater quantity, location, and timing (NCP 6); regulation of freshwater and coastal water quality (NCP 7); formation, protection, and decontamination of soils and sediments (NCP 8); regulation of hazards and extreme events (NCP 9); regulation of detrimental organisms and biological processes (NCP 10); energy (NCP 11); food and feed (NCP 12); materials, companionship, and labor (NCP 13); medicinal, biochemical, and genetic resources (NCP 14); learning and inspiration (NCP 15); physical and psychological experiences (NCP 16); supporting identities (NCP 17); maintenance of options (NCP 18).

- **Nature loss –** The loss and/or decline of the state of nature.
- **Nature positive -** A high-level goal and concept describing a future state of nature (e.g., biodiversity, nature's contributions to people) that is greater than the current state.
- **$NH_3$ –** Ammonia.
- **$NO_X$ –** Nitrogen oxides.
- **Physical traceability** is when a company has the ability to identify, track, and collect information on activities (e.g. activity data or emission factors) related to material flows of goods and services in its value chain, across its upstream and downstream processes and products.
- **Pressures -** A human activity that directly or indirectly degrades nature. According to IPBES, five key pressures contribute most to the loss of nature globally: land and sea use change; direct exploitation of organisms; climate change; pollution; and invasion of alien species. While we generally follow IPBES definitions for these categories, we take a slightly broader conceptualization of "direct exploitation" to include both biotic and abiotic resources, such as water use—we thus use the term "resource exploitation."
- **Primary data -** Data collected specifically for the assessment being undertaken. Generally, primary data will be collected from site-level measurement on a specific issue area through the use of direct measurement (e.g., volume of freshwater used for irrigation each month).
- **Production unit -** A plantation, farm, ranch, or forest management unit, or production site. This includes all plots used for agriculture or forestry that are under one management, located in the same general area, and share the same means of production. It also includes natural ecosystems, infrastructure, and other land within or associated with the plantation, farm, ranch, site, or forest management unit (Adapted from AFi).
- **Reduce -** Minimize impacts, from a previous baseline value, without eliminating them entirely.
- **Regenerate -** Actions designed within existing land uses to increase the biophysical function and/or ecological productivity of an ecosystem or its components, often with a focus on specific nature's contributions to people (e.g., on carbon sequestration, food production, and increased nitrogen and phosphorus retention in regenerative agriculture) (Adapted from FOLU, 2019).
- **Reporting -** Preparing of a formal written document typically connected to desired objectives, outcomes, or outputs, such as those connected to targets and goals.
- **Restore -** Initiate or accelerate the recovery of an ecosystem with respect to its health, integrity, and sustainability with a focus on permanent changes in state. (Adapted from the Society of Ecological Restoration).
- **Response option –** Action that a company could take to improve the state of nature on land that would likely be reflected in the indicator used to measure progress on its targets.
- **SBTi -** Science Based Targets initiative.

- **SBTN -** Science Based Targets Network.
- **Science-based targets -** Measurable, actionable, and time-bound objectives, based on the best available science, that allow actors to align with Earth's limits and societal sustainability goals.
- **Secondary data -** Data that was originally collected and published for another purpose or a different assessment, e.g., derived from modelled or proxy-level data.
- **Short vegetation -** Areas of land with vegetation shorter than 5 meters and can include areas of land dominated by grass or shrubs.
- **Site(s) -** Operational locations within a company's value chain/spheres of control and influence (including direct operations). Sites can include operations from any phase of a product's life cycle, from extractive operations (e.g., mines), material processing (e.g., mills), production facilities (e.g., factories), logistics facilities (e.g., warehouses), wholesale and retail (e.g., stores), and recycling/end of life (e.g., material recovery).
- **Snow/ice -** Areas covered by permanent snow or ice.
- **$SO_2$ –** Sulfur dioxide.
- **Stakeholder engagement -** Stakeholder engagement involves interactive processes of engagement with relevant stakeholders through, for example, meetings, hearings, or consultation proceedings. Effective stakeholder engagement is characterized by two-way communication and depends on the good faith of the participants on both sides (TNFD).
- **Stakeholders -** Stakeholders are persons or groups who are directly or indirectly affected by a project, as well as those who may have interests in a project and/or the ability to influence its outcome, either positively or negatively (TNFD).
- **State of nature indicators -** State of nature indicators describe the general conditions of nature in physical, chemical, or biological terms. These change in response to pressures. Throughout the target-setting methodology, SBTN utilizes the DPSIR causal framework. Important state indicators in the SBTN methods include water availability, terrestrial ecosystem intactness, net primary productivity, soil organic carbon content, water quality, and ecosystem extent or connectivity[1].
- **States -** Unless otherwise specified, we use the term "state" to mean "state of nature" in three key categories: species (abundance and extinction risk), ecosystems (extent, integrity, and connectivity), and nature's contributions to people.
- **Structure of an ecosystem -** This comprises the three-dimensional aspect of ecosystems—the biotic and abiotic elements that form the heterogeneous matrix supporting the composition and functioning. Structure is dependent on habitat area, intactness, and fragmentation.
- **Target -** In global (e.g., UN) sustainability framings, a more specific quantitative objective, usually nested under a goal, with defined measurement and an associated indicator. Example: By 2020, pollution, including from excess nutrients, has been brought to levels that are not detrimental to ecosystem function and biodiversity (Aichi Target 8).
- **Target boundary -** The corporate scope of the target, specific to each issue area. The target boundary may be defined in terms of the value chain aspect covered, as well as the specific locations, products, brands, etc., that will be in focus in a given time period.
- **Target dates -** Target dates are the time by which companies must achieve their Land targets.

[1] Terminology note: While SBTN uses the term "state" in alignment with the DPSIR framework, other initiatives, such as TNFD and the Capitals Coalition, use the term "changes in natural capital" to describe these same factors within the causal chain of environmental change.

- **Threshold -** Level of an environmental indicator representing attainment of the desired state of nature.
- **Transform -** Actions contributing to system-wide change, notably the drivers of nature loss, e.g., through technological, economic, institutional, and social factors and changes in underlying values and behaviors. (Adapted from the Intergovernmental Panel on Climate Change (IPCC) and IPBES 2019).
- **Unit process -** The smallest (least aggregated) unit in a production system, for which input and output data are quantified (OpenLCA 2 manual).
- **Upstream -** This covers all activities associated with suppliers, e.g., production or cultivation, sourcing of commodities of goods, and transportation of commodities to manufacturing facilities.
- **Validation -** An independent process involving expert review to ensure the target meets required criteria and methods of science-based targets.
- **Value chain -** Production of “economic value” along a series of activities, sites, and entities. The value chain can be divided into three “segments”: upstream, direct operations, and downstream. Each of these segments involves places where economic activities managed or relied on by the company occur. Most value chain frameworks cover a suite of activities starting with the raw materials and extending through end-of-life management, that (a) supply or add value to raw materials and intermediate products to produce final products for the marketplace and (b) are involved in the use and end-of-life management of these products.
- **Verification -** An independent third-party confirmation of either or both of: (a) baseline values of a target indicator (e.g., a company’s water or GHG inventory), and (b) progress made toward achieving the target.
- **Water -** Surface water present 20% or more of the year, outside wetlands.
- **Wetlands -** Transitional ecosystems with saturated soil that can be inundated by water either seasonally or permanently and can be covered by short vegetation or trees.
- **Working lands -** Human-modified lands, which can include farms, forests, rangelands, and infrastructure, that are managed to provide goods and services.
- **WWF -** World Wildlife Fund, or World Wide Fund for Nature.
- **Yield -** This refers to intensity of production per unit of land area. It is defined as the amount of product produced in a year divided by the amount of land occupied by that product. For crops, it refers to the amount produced divided by the harvested area. For livestock products, it refers to the amount produced divided by the total area needed for livestock production (both to house the animals and to produce the crop- and/or pasture-based animal feeds.

# Chapter 1. Introduction

*This chapter provides an introduction to- and overview of the Accounting Guidelines for Impacts on Land-use and the Environment (the guidelines).*

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## 1.0 Overview

The global scientific consensus is clear that we are in a climate and nature emergency. Globally, temperatures are set to exceed the 1.5˚C threshold. Coupled with this, the global environmental crisis has seen wildlife populations collapse by an average of 73% since 1970 (WWF, 2024) and up to one million species come under risk of extinction (IPBES, 2019). In the context of terrestrial ecosystems, urgent action is needed to:

- Halt the loss of natural ecosystems, including through deforestation and conversion.
- Facilitate land remediation and restoration.
- Improve land management and use land more efficiently, justly, and sustainably.

The climate and nature crises share drivers and potential solutions. Land use change, ecosystem destruction and poor land management not only contribute to the loss of nature and biodiversity but also result in the release of large amounts of carbon dioxide ($CO_2$) into the atmosphere. The impacts of climate change, including more intense and frequent rainfall events and droughts increase soil erosion, while rising temperatures accelerate the decomposition of organic matter, reducing soil carbon storage. At the species level, the impacts of climate change can result in range shifts and even extinctions. These impacts threaten the resilience and stability of ecosystems and ultimately, human societies. Given these intimate connections and the urgency of these issues, any potential solutions must address these crises simultaneously. Fortunately, many synergies exist in possible strategies.

The SBTN Land Accounting Guidance for Impacts on Land-use and the Environment ("the guidelines") provide corporate-level accounting methods for land-based impacts associated with companies' direct operations and upstream value chain activities. They have been developed to assist companies in developing a robust and consistent approach to calculate their impacts on land associated with land use change, land area and quality, and landscape engagement activities.

The aim of these guidelines is to provide a methodology that will enable companies to understand and measure important components of their land impacts. Within the context of SBTN's Land Targets, the guidelines support the development of baselines and measurement of footprints for each target. Specifically, the guidelines provide methods for companies to measure the following impact categories:

- Land use change (deforestation and conversion)
- Land area and quality
  - Land footprint
  - Natural land cover
  - Soil organic carbon
  - Soil erosion
  - Terrestrial acidification
- Landscape engagement

The land impact categories have been included based on their capacity to address the following criteria:

- Maximum coverage of pressures that are responsible for most companies' impacts on land.
- Availability of quantifiable and measurable metrics that can be feasibly impacted by company activities to make progress against.
- Alignment with active and relevant corporate sustainability standards and initiatives.
- Ability to incentivize action across the Action Framework (AR3T[2]).

In addition, the guidelines provide methods for companies to measure improvements from the implementation of select response options.

The guidelines complement the measurement of climate-related impacts by assessing wider, non-greenhouse gas (GHG) impacts on land-use and emissions. The broader set of actions these methods motivate include the reduction and treatment of pollution and effluents, erosion control, and other actions that support species and ecosystem integrity, including at a landscape scale.

Critically, these methods expand the focus beyond forests to include all terrestrial ecosystems (e.g., grasslands, wetlands and shrublands), especially as they relate to the worked lands (e.g., cropland, rangeland, pasture and managed forest) that facilitate the production of many goods used by companies and consumers.

## 1.1 Structure of the guidelines

An overview of the structure of the guidelines is provided in Figure 1.

[2] Action Framework AR3T: Avoid and Reduce pressures on nature loss; Regenerate and Restore so that nature can recover; Transform underlying systems in which companies are embedded to address drivers of nature loss.

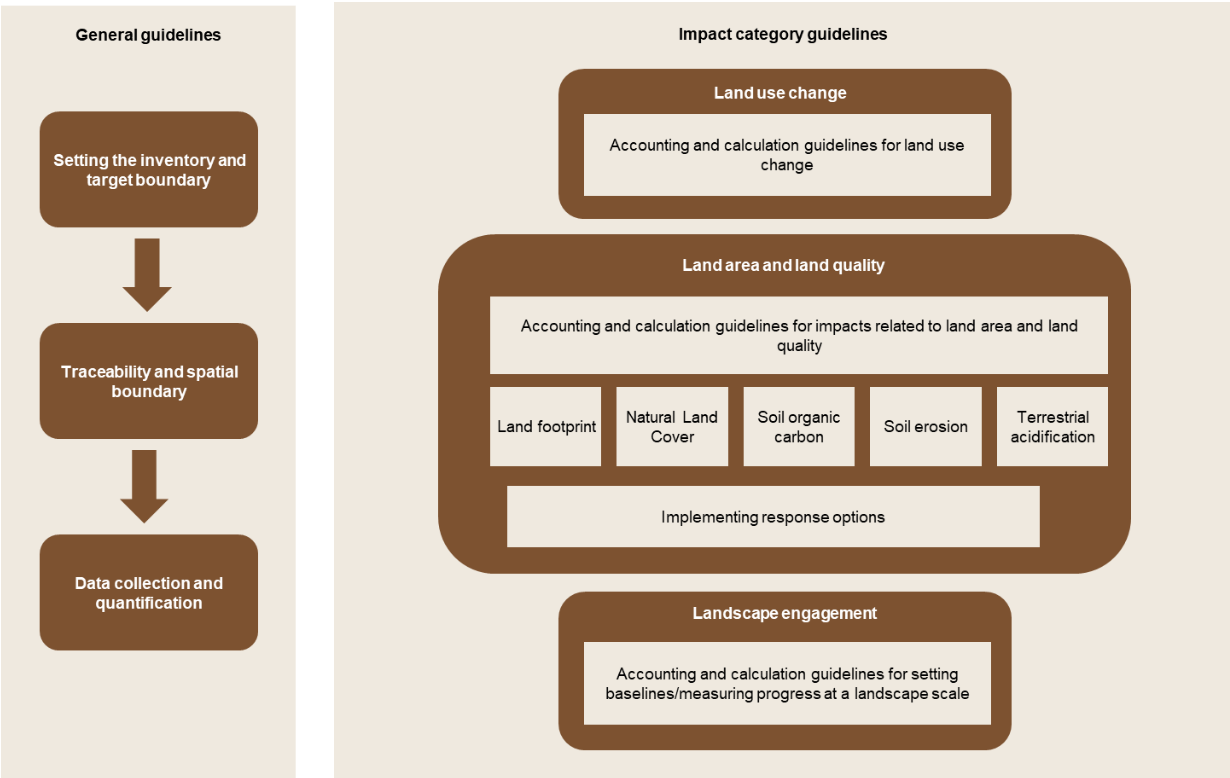



**Figure 1 Structure of the guidelines**

## 1.2 Use of the guidelines and intended audience

The guidelines can be used by any organization of any size that has land sector activities within its operations or value chain.

The guidelines can be used by companies to calculate their land impacts for the purposes of setting land targets in line with the (draft) *Science Based Targets Network (2025) Step 3: Measure, Set, & Disclose: Land (Version 2.0)* "((draft) Step 3: Land (Version 2.0) technical guidance). The guidelines should be used in conjunction with the accompanying (draft) Step 3: Land (Version 2.0) technical guidance as they provide the detailed methodology and associated data requirements for each impact category.

## 1.3 Relationship with other standards and guidance

The SBTN Step 3: Measure, Set, & Disclose: Land (Version 1.0), (draft) Step 3: Land (Version 2.0) technical guidance and the Draft Greenhouse Gas Protocol Land Sector and Removals Guidance (2022) ("(draft) GHG Protocol LSRG (2022)") provide the foundation for the development of the guidelines. They build on these guidance documents by providing additional methodological guidance for non-GHG land-based impacts. Specifically, the guidelines align with the (draft) GHG Protocol LSRG recommendations, requirements and guidance on:

- Traceability and spatial boundaries, adapted for SBTN land impacts (Chapter 3)
- Data collection and quantification, adapted for SBTN land impacts (Chapter 4)
- Accounting for land use change at an area-level and allocation of impacts, adapted for SBTN land impacts (Chapter 5)
- Calculating land footprint, adapted for SBTN land impacts (Chapter 6)

- Calculating soil carbon stock changes (Chapter 6)

Throughout these guidelines, recommendations, requirements and guidance have been included and adapted from the (draft) GHG Protocol LSRG (2022) - both the published draft reports (Part 1 and Part 2) as well as updated provisional text that remains under review by the GHG Protocol ("(draft) GHG Protocol LSRG (forthcoming)"). **As such, it is important to note that any reference to the (draft) GHG Protocol LSRG (2022) and (draft) GHG Protocol LSRG (forthcoming) is subject to change, pending final publication by the GHG Protocol.**

Additionally, the guidelines build on, and align with, the SBTN Step 1 and 2 guidance, by providing more detailed requirements and recommendations for companies to measure their land impacts. Companies that use precise data to describe their impacts in Step 1 may be able to use this information to satisfy some of the requirements outlined in the guidelines. Table 1 provides a high-level summary of data input requirements for companies under SBTN Step 1 and Step 2 as well as data input requirements for the guidelines. For full details on data requirements please refer directly to Step 1 and Step 2, and the relevant Chapter in the guidelines.

The guidelines also draw on Accountability Framework initiative guidance, particularly in relation to guidance on conversion and deforestation as well as additional research from literature and input from expert stakeholders.

The intention of aligning to- and referencing existing guidance from the GHG Protocol, Accountability Framework initiative and others in the guidelines is to provide consistency in approaches and to reduce unnecessary burden where possible on companies and individuals carrying out this work.

**Table 1 High-level data input requirements of SBTN Step 1 and Step 2, and the guidelines**

| Value chain stage | SBTN Step 1 | SBTN Step 2 | Accounting Guidelines for Impacts on Land-use and the Environment | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Land use change | Land footprint | Natural land cover | Soil organic carbon and soil erosion | Terrestrial acidification | Landscape engagement |
| **Direct operations** | List of all directly owned or operated sites, location, and the activity or product/commodity involved; locations of main off-site activities and the activity involved | Long list of pressure and state of nature estimates per operational site, output from Step 1 | Location of all sites where conversion-driving commodities are produced (ha)<br><br>Areas converted after cutoff date (ha) | Volumes of commodities produced by production location (Metric tons)<br><br>Data on operational sites where commodities are produced (ha) | Location of all production units in direct operations (ha) | Land use and duration by location and intensity (ha*yr) | Ammonia ($NH_3$), nitrogen oxides ($No_x$) and sulphur dioxide ($SO_2$) emissions (kg)<br><br>Location of emission sources (e.g. ecoregion)<br><br>Land footprint (ha) | Location of prioritized landscapes for engagement<br><br>Selected landscape-level metrics |
| **Upstream** | List of procurement (commodities/goods and activities) paired with known or expected sourcing location, and volume on each category | Long list of pressure and state of nature estimates per procurement or activity, output from Step 1 | Sourcing area and volumes of conversion-driving commodities purchased (ha and metric tons or equivalent from each area)<br><br>(Optional) Production unit (ha) | Volumes of commodities purchased (Metric tons)<br><br>Yield of each product purchased (Metric tons per ha per yr) | (Optional) Companies can follow the direct operations approach if they have the requisite traceability and data | (Optional) Companies can follow the direct operations approach if they have the requisite traceability and data | (Optional) Companies can follow the direct operations approach if they have the requisite traceability and data | Location of prioritized landscapes for engagement<br><br>Selected landscape-level metrics |

## 1.4 Supporting calculation tools and resources

As part of the final publication of the Step 3: Land (Version 2.0) technical guidance and the guidelines, SBTN will provide further guidance on supporting tools and resources for companies to set land targets. As these methods require technical comprehension and proficiency, a range of tools and technical resources may be necessary to effectively navigate the process. The guidance will detail how to evaluate tools and resources within the context of the land target implementation process and specific private sector archetypes.

## 1.5 Guidelines development process

The guidelines provide an important starting point for the development of accounting and calculation guidelines for target setting around land-based impacts on nature. The guidelines may be updated in future iterations to respond to the latest developments in accounting and target setting methodologies, new scientific approaches and where changes can be made to support increased and more effective corporate action.

SBTN adheres to a broad and inclusive multi-stakeholder engagement process as part of the development of the guidelines. In December 2024, SBTN Land Hub conducted an expert stakeholder review process of the draft guidelines. Following this review process, the guidelines were updated ahead of public consultation in April 2025.

SBTN would like to thank those stakeholders for their valuable feedback and insights throughout the development of the guidelines.

# Chapter 2. Setting the Inventory and Target Boundary

*This chapter provides guidance for companies to set their organizational and inventory boundary as well as the target boundary for companies setting SBTN Land targets.*

| Section | Description |
|---|---|
| **2.0** | **Organizational boundary** provides guidance for companies to determine their organizational boundary, aligning with SBTN Step 1 and the GHG Protocol guidance, covering:<br>• Financial control approach<br>• Operational control approach<br>• Equity share approach<br>This section also provides guidance on the Business Unit Approach. |
| **2.1** | **Inventory boundary** provides guidance for companies to set the inventory boundary and outlines the value chain stages included in the guidelines |
| **2.2** | **Target boundaries** for companies setting SBTN Land targets - provides guidance on setting the target boundary across direct operations and upstream value chain (target boundary A and target boundary B). |

## 2.0 Organizational boundary

The organizational boundary refers to the widest extent of a company's direct operations included in the assessment and must be defined before the company begins to implement the methods within the guidelines. This boundary is the basis for companies to create an inventory of direct operations and upstream value chain activities (see Section 2.1). The following guidance is derived from SBTN Step 1 Technical Guidance and adapted where relevant for these guidelines.

The organizational boundary defines which business operations are owned or controlled by the company. In this context, "business operations" refers to entities such as the company implementing the methods, subsidiaries, and affiliated or associated companies, as well as joint ventures and partnerships, fixed asset investments, or franchises. Companies should note that whether any one of these operations is determined to be within the organizational boundary or not depends on the approach used to define the boundary.

Many companies will have experience in defining an organizational boundary as part of GHG accounting and financial reporting, or measuring, disclosing, or actively managing their environmental footprints through initiatives such as the Science Based Targets initiative, GHG Protocol, the Accountability Framework initiative, or the Taskforce on Nature-related Financial Disclosures.

There are three possible approaches to defining this boundary:

- **Financial control approach** – all business operations over which the company has the ability to direct the financial and operating policies with the intention of gaining economic benefits from these activities.
- **Operational control approach** – all business operations over which the company, or a company subsidiary, has the authority to introduce and implement operating policies.
- **Equity share approach** – the share (%) of the company's economic interest in, or legal ownership of, each business operation.

Companies must indicate their organizational boundary and determine whether each of their business operations is part of it following one of the three approaches laid out by the GHG Protocol. Companies must demonstrate that, depending on the approach selected, their organizational boundary is comprehensive of all their business operations.

Companies that have already set science-based targets for climate using the GHG Protocol are strongly recommended to use the same organizational boundary for setting science-based targets for nature. This means that if a company is using the equity control approach for its science-based targets for climate, then it must use the same one for its science-based targets for nature.

Companies that have not defined an organizational boundary in the past are recommended to use either the financial or operational control approach.

The choice of approach will dictate which subsidiaries and other activities are included within the scope of direct operations for accounting. By delimiting what is included within the company's direct operations, the organizational boundary will also define which activities will be accounted for when looking at the upstream segment of the company's value chain.

For companies using the guidelines to set SBTN Land targets, they will have already defined their organizational boundary during SBTN Step 1a Materiality Assessment. The scope of the business covered within the science-based target-setting methodology may narrow as companies undertake the value chain assessment as illustrated in the Figure below. Companies may narrow the boundary of assessment by following the Business Unit Approach during Step 1b, 2 and 3 of the SBTN methods. The objective of the Business Unit Approach is to enable large, complex companies to begin target-setting by focusing on the most prepared and/or impactful parts of their business. Business units correspond to geographic regions, industries, or brands. Companies should note that using the business unit approach will limit the claims they can make about the application of science-based targets for nature.


**Figure 2 Narrowing the scope of the target-setting process. The process of setting science-based targets for nature requires companies to start with as broad a scope as possible. The range of economic activities to be evaluated and managed through science-based targets becomes narrower as companies move through the subsequent steps of the methodology, becoming more focused on the activities and locations that matter the most for nature and society as well as their businesses' target-setting strategies ([SBTN Step 1](#)).**

Further details on how to assess the organizational boundary and adopt the Business Unit Approach can be found in SBTN Step 1 Technical Guidance and the GHG Protocol Corporate Accounting and Reporting Standard Revised Edition.

## 2.1 Inventory boundary

For the purpose of the guidelines and in line with the GHG Protocol (2015), the inventory boundary refers to an imaginary line that encompasses the direct and indirect impacts that are included in a company's inventory for accounting land impacts.

The value chain encompasses the entire network of activities involved in producing and delivering a product or service. This includes upstream suppliers, direct operations, and downstream activities. Please refer to Table 2 for the definitions of stages of the value chain.

**Table 2 Value chain stages**

| Value chain | Definitions |
|---|---|
| **Operational site** | Operational locations within a company's value chain/spheres of control and influence, including direct operations. Sites can include operations from any phase of a product's life cycle, from extractive operations, (e.g. mines), material processing (e.g. mills), production facilities (e.g. factories), logistics facilities (e.g. warehouses), wholesale and retail (e.g. stores), and recycling/end of life (e.g. material recovery). |
| **Direct operations** | All activities and sites (e.g. buildings, farms, mines, retail stores) over which the enterprise has operational or financial control. This includes majority-owned subsidiaries. |
| **Upstream** | In the accounting guidelines, upstream sourcing activities are separated based on whether they occur before or after first point of aggregation and are therefore delineated as:<br>• sourcing from producers and from "first point of aggregation"<br>  ○ commodity-specific "first points of aggregation" are listed in Annex 1b and include refineries and grinders, milling, meat packing and processing facilities, milk and dairy processing facilities, and feed mixing.<br>• sourcing from stages of the value chain that are downstream from the first point of aggregation |
| **Downstream** | This covers all activities that are linked to the sale of products and services produced by the company. This includes the use and re-use of the product and its end of life to include recovery, recycling, and final disposal. |

In line with current SBTN guidance, **the guidelines only cover direct operations and upstream value chain activities**. For some sectors, downstream impacts may constitute a substantial proportion of total value chain impacts on land. Companies are encouraged to use the guidelines in addition to seeking complimentary solutions and methods to assess downstream impacts in the absence of specific SBTN guidance.

For companies using the guidelines to set SBTN Land targets, during Step 1 they will have screened their portfolio of economic activities for materiality (Step 1a: Materiality Screening), and estimated their contributions toward key issues through an assessment of pressures (e.g. land use change and soil pollution) and states/impacts associated with each category of activity (Step 1b: Value Chain Assessment). To complete these sub-steps, SBTN provides detailed guidance to support the mapping of value chain activities and locations. The guidelines align with- and build on SBTN Step 1 guidance by requiring more granular data on direct operations and upstream value chain activities to assess land impacts which are outlined in Chapters 5-7.

## 2.2 Target boundaries

For companies using the guidelines to set SBTN Land targets, during Step 2 they will define their target boundaries, i.e., the corporate scope of the target, specific to each issue area (i.e., land, freshwater, and oceans). The target boundary may be defined in terms of the value chain stage covered (e.g., direct operations and upstream value chain), as well as the specific locations, business units, etc., that will be in focus in a given time period.

All companies setting SBTN Land targets must define a target boundary within their direct operations for each pressure category (e.g. land use and land use change and soil pollution) required for assessment based on the outcome of SBTN Step 1. The direct operations target boundary for each pressure must include all material activities in the company's direct operations.

For the upstream value chain, SBTN Step 2 provides two types of target boundaries that consider differences in information availability and the range of uncertainty in upstream data (e.g. quality, resolution):

- **Target boundary A:** A more precise boundary that supports immediate science-based targets for nature to be set. Target boundary A must include all locations for which the company has sufficiently precise geographic information about the locations of origin associated with specific commodity volumes or upstream activities. Sufficient precision means that these data are known or estimated at least at the subnational level. Companies purchasing raw commodities are required to obtain or estimate data consistent with requirements for upstream target boundary A for some ( >0%) of their upstream activities before proceeding to Step 3 target setting. For companies more than 1 tier from raw commodity sourcing, there will be no requirement for target boundary A coverage to proceed to Step 3. All companies are recommended to have at least 50% of their upstream volumes in target boundary A.

- **Target Boundary B:** A less precise boundary that necessitates further actions on traceability and transparency to facilitate science-based target setting. Target boundary B must only include locations for which the company does not have sufficiently precise geographic information about the production units or sites of origin of specific commodity volumes or upstream activities, and where this location information cannot easily be refined to subnational level. Companies must use target boundary B when they currently do not have the information needed to set place-based targets for their upstream activities and cannot readily obtain that information.

For companies using the guidelines to set SBTN Land targets, the focus of the guidelines is for direct operations target boundary and upstream target boundary A. Under SBTN, companies must increase the sourcing volumes found in upstream target boundary A over time through increasing their value chain transparency and traceability to achieve science-based targets. Guidance on improving upstream traceability and additional guidance on target boundaries is available in SBTN Step 2 Guidance.

# Chapter 3. Traceability and Spatial Boundary

*This chapter provides guidance on traceability and outlines the spatial boundaries covered in the guidelines.*

| Section | Description |
|---|---|
| 3.0 | **Overview** provides high-level guidance on traceability and spatial boundaries, including principles for selecting the appropriate scale of analysis and traceability in line with the GHG Protocol |
| 3.1 | **Traceability and spatial boundaries** provides guidance on the type of traceability and spatial boundaries considered in the guidelines |
| 3.2 | **Spatial and statistical data needs based on traceability and spatial boundary** summarizes the guidelines' requirements and recommendations on the use of spatial and statistical data depending on companies' traceability and spatial boundary |

## 3.0 Overview

Depending on the impact category and company position within the value chain, the level of traceability and data specificity will vary. Companies can define the relevant spatial boundaries based on their organizational boundary (as determined in Chapter 2) and the traceability they have within their value chain.

The level of traceability and associated spatial boundary is context-specific, based on the type of land management system producing the goods or services and the reporting company's position in the value chain. In line with the (draft) GHG Protocol LSRG (forthcoming), companies should select the scale of analysis and level of traceability that enables the following:

- The most accurate, precise accounting for land impacts in the specific context.
- The most credible allocation for land impacts.
- The most effective and efficient way to improve land management practices and foster collaborative action and investment for reducing land impacts within value chains. Where possible, SBTN encourages companies to support or directly participate in targeted, impactful, and credible landscape initiatives to minimize trade-offs and deliver positive environmental and social co-benefits and support connectivity of natural and restored lands.

In line with the (draft) GHG Protocol LSRG (forthcoming), when engaging with value chain partners, companies should ensure equity and acknowledge the rights of landholders by obtaining free, prior, informed consent (FPIC); providing fair compensation; and follow best practices. Additional guidance is available through SBTN Stakeholder Engagement Guidance, Food and Agriculture Organization, the United Nations General comment No. 26 (2022) on Land and Economic, Social and Cultural Rights and the United Nations Guiding Principles on Business and Human Rights.

## 3.1 Traceability and spatial boundaries

The ability to accurately account for land impacts associated with a company's activities depends on their traceability to the relevant lands and activities in their direct operations or value chain. For these guidelines, traceability to a relevant spatial boundary can be defined by physical traceability as summarized below (adapted from the (draft) GHG Protocol LSRG (forthcoming)).

- **Physical traceability** is when a company has the ability to identify, track, and collect information on activities (e.g. activity data or emission factors) related to material flows of goods and services in its value chain, across its upstream and downstream processes and products.

For sourcing companies, traceability may be facilitated by internal company systems, business-to-business disclosure by suppliers, third-party certification programs, or other methods for attaching information about origins to product or commodity volumes. Traceability to the production unit of origin (see Table 3) is preferable in most cases and allows for the highest level of supply chain control and the most precise land impact accounting (adapted from the Accountability Framework initiative, 2022).

These guidelines consider the following spatial boundaries: global, national, sourcing area (including subnational jurisdiction) and production unit as summarized in Table 3.

**Table 3 Spatial boundaries, listed in order of coarse to finer resolution data (adapted from (draft) GHG Protocol (forthcoming))**

| Spatial boundary | Level of traceability |
|---|---|
| **Global** | **No knowledge of region of origin** |
| **Country** | **Known country of origin**<br>• A predefined, spatially explicit area based on a political boundary where commodities or derived products are sourced from. This includes political boundaries based on a country of origin. |
| **Sourcing area** | **Known sourcing area (subnational jurisdiction)**<br>• A predefined, spatially explicit area to at least subnational jurisdiction (e.g. municipality, state, province) where commodities or derived products are sourced from. |
| | **Known sourcing area (first collection point or processing facility)**<br>• A predefined, spatially explicit area that supplies a commodity to the first point of aggregation or first processing facility in the value chain.<br>• Sourcing region boundaries may be defined relative to the tier of the value chain that is inclusive of multiple first points of aggregation or first processing facilities with overlapping areas that supply commodities. |
| **Production unit** | **Known production units of origin**<br>• A plantation, farm, ranch, forest management unit, or production site. This includes all plots used for agriculture or forestry that are under one management, located in the same general area, and share the same means of production. It also includes natural ecosystems, infrastructure, and other land within or associated with the plantation, farm, ranch, site, or forest management unit (adapted from the Accountability Framework initiative, 2024a). See Figure 3 below. |

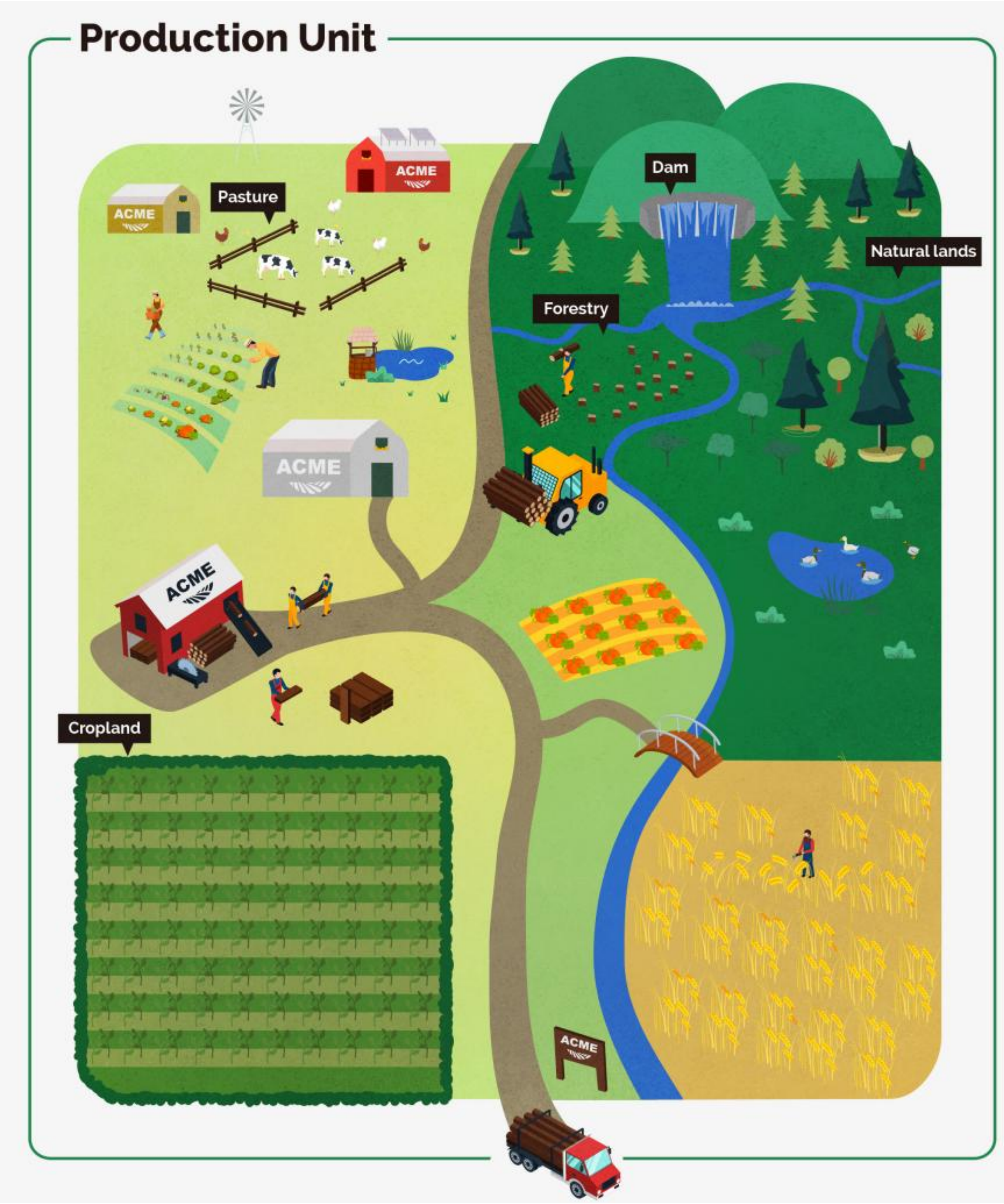



**Figure 3 Illustration of the SBTN definition of a production unit**

Under the guidelines, the most granular spatial boundary permitted is the production unit as defined in Table 3. In line with the Accountability Framework initiative, a production unit can be a contiguous land area (regardless of any internal subdivisions) or a group of plots interspersed with other land units in the same area or landscape and under the same management.

Farms and other production units may consist of multiple plots or fields under common ownership and management. The calculation of land impacts should be assessed at the level of the entire production unit. In the example provided in Figure 4, the farm (and its products) cannot be considered deforestation-free since the farm is actively engaged in deforestation on Plot 2 (Accountability Framework initiative, 2024a).

The assessment at the level of the production unit seeks to avoid potential challenges associated with accounting at a smaller scale – such as at the plot or field level. For example, when accounting at the sub-farm level, products could be classified as being deforestation-free when there is new or ongoing deforestation being conducted on the same farm, by the same owner or operator, using the same workers and equipment (Accountability Framework initiative, 2024a).

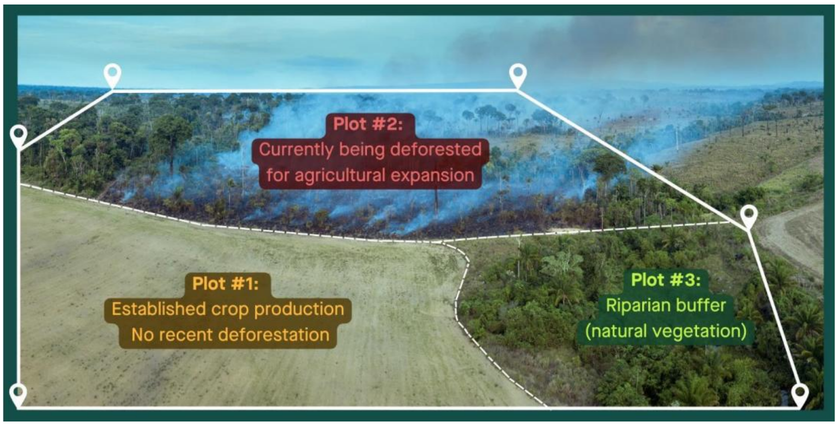



**Figure 4 Example of an assessment of deforestation at the level of a production unit (adapted from the Accountability Framework Initiative, 2024a)**

## 3.2 Spatial and statistical data needs based on traceability and spatial boundary

Depending on a company's position within the value chain and its level of traceability to a particular spatial boundary, the guidelines provide requirements and recommendations for spatial and statistical data specific to each impact category - detailed in Chapters 5-7.

Companies adopting statistical approaches to calculate their land impacts must ensure that data used to calculate such impacts relates to comparable lands, sourcing areas and commodities produced or sourced. When using statistical data, companies should use the most spatially explicit data available for each commodity or product produced or sourced. For example, sourcing data that relates to lands within the same sourcing region or jurisdictional boundary that produce the commodity sourced by the reporting company. Companies should ensure the exclusion of data that relates to, for example, lands incapable of producing the relevant commodity, lands with harvest restrictions and lands with other protective status.

Companies using the guidelines to set SBTN Land targets that are unable to source relevant statistical data that meets these requirements must provide a clear explanation of this in their target submission, outlining data gaps and rationale for using the selected data, and future actions to close data gaps.

# Chapter 4. Data Collection and Quantification

*The appropriate use of data and methods is critical to ensure a robust calculation of land impacts. This chapter provides an overview and guidance on data collection and quantification. Guidance is based on the (draft) GHG Protocol LSRG (2022) and (forthcoming), and SBTN guidance. For further information and guidance please see the (draft) GHG Protocol LSRG (2022), SBTN Step 1 guidance and SBTN Data and Tool Criteria.*

| Section | Description |
|---|---|
| 4.0 | **Data collection** provides data collection principles |
| 4.1 | **Quantification** introduces the two broad methods of quantification:<br>• Direct measurement<br>• Calculation – including activity-based, model-based and remote sensing based approaches |
| 4.2 | **Data types** provides an overview of data types – covering primary and secondary data |
| 4.3 | **Supply chain traceability** provides an overview of supply chain traceability |
| 4.4 | **Data selection** provides considerations for companies when selecting either primary or secondary data |
| 4.5 | **Data quality** provides guidance and criteria for companies to use when assessing data quality |
| 4.6 | **Method selection** outlines the advantages and disadvantages of quantification approaches, provides key considerations for method selection and provides example of data types for each quantification method |
| 4.7 | **Allocation** introduces the concept of allocation (mass and economic), including a decision tree for companies |
| 4.8 | **Recalculating the baseline** summarizes when companies need to recalculate the baseline |
| 4.9 | **Method application and reporting guidelines** provides general method application and reporting guidelines for companies |

## 4.0 Data collection

Companies are encouraged to (adapted from (draft) GHG Protocol LSRG (forthcoming)):

- Aim for higher accuracy data and methods.
- Evaluate data quality and improve their inventory over time.
- (Where allocation is required) adopt the most appropriate method (e.g. physical or economic) to partition impacts across commodities or derived products.
- Adopt a conservative / precautionary approach when selecting and applying methods and data.

## 4.1 Quantification methods

There are two main approaches to quantify impacts generated by a company's value chain activities, both applicable to direct operations and upstream activities. Companies will likely combine these two approaches as necessary: i) direct measurement and ii) calculation.

- **Direct measurement** involves monitoring changes through direct observation or sampling. This can include repeated measurements in specific areas, data analysis, and quality control procedures. Remote sensing may also be used, though it often requires calibration with ground data.
- **Calculation** uses empirical, process-based or other models to calculate land impacts.

A hybrid approach can combine both methods, using direct measurements to refine or calibrate models for more accurate assessments. Table 4 provides a description and example of different quantification methods.

**Table 4 Description of quantification types and approaches (adapted from (draft) GHG Protocol LSRG, 2022)**

| Quantification | Quantification approach | Description of relevant methods | Examples |
|---|---|---|---|
| **Direct measurement** | **Measurement-based approaches** | Methods that directly quantify carbon stock changes using monitoring of GHG fluxes, mass balance or stoichiometry. Direct measurements of combustion emissions such as $NO_x$, $NH_3$ and $SO_2$. | Use of a gas analyzer to measure $SO_2$ emissions |
| **Calculation** | **Activity-based calculation approaches** | Methods that multiply activity data by an emissions factor or carbon stock change factor to determine emissions or carbon stock changes respectively for a given process. | LCA database derived emissions factors |
| | **Model-based calculation approaches** | Methods that use mathematical modeling techniques to estimate carbon stock changes resulting from land management changes. | RothC model for soil carbon |
| | **Remote sensing-based calculation approaches** | Data collection methods that use satellite or aerial data on activities on the land and estimate carbon stock changes or soil erosion which are then combined with direct measurements, activity -based approaches or modeling approaches. | LiDAR; Satellite deforestation monitoring |

## 4.2 Data types

Data are classified as either primary data or secondary data:

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

For example, soil samples collected from land the company sources from are primary data, but measurements from similar land in the same region that the company does not source from would be defined as secondary data. While data can be classified as either primary or secondary, the calculation methods might require a mixture of both data types, resulting in a hybrid calculation ((draft) GHG Protocol LSRG, 2022). For example, to calculate land footprint associated with purchased wheat, companies may use primary data in terms of volumes of wheat purchased and multiply the volume by average yield data sourced from national datasets (secondary data) to estimate the hectares of land sourced from.

A data management plan can help document data sources, collection protocols and data quality ((draft) GHG Protocol LSRG, 2022). Primary data reflects a company's activities more accurately but can be harder to obtain. Secondary data are easier to access but may not capture company-specific changes or improvements. Over time, better traceability can improve the availability and quality of primary data, offering more accurate, location-specific insights. Under most circumstances, primary data are preferred because they are site-specific and companies can be confident that the methods deployed were robust and fit for purpose. However, secondary data may be utilized when primary data collection is found to be cost prohibitive or unfeasible.

## 4.3 Supply chain traceability

From a supply chain perspective, primary data are categorized based on a supplier's position relative to the reporting company in the supply chain. Primary data from a tier 1 supplier refer to primary data that come from the company directly supplying the reporting company. Primary data from a tier 2 supplier refer to primary data that come from a company that supplies the reporting company's tier 1 suppliers, and so on, tracing back to the original producer of the raw materials.

Improving traceability across supplier tiers allows companies to gather more reliable primary data. If a supplier cannot supply the required data, companies may still obtain relevant information about practices and conditions to improve estimates. When the supplier is unknown, companies can use secondary data while working to improve value chain traceability and supplier data quality ((draft) GHG Protocol LSRG, 2022).

## 4.4 Data selection

Data collection efforts will vary depending on the sector, company location within the value chain and the level of traceability available. Companies should aim to improve traceability by gathering more primary data to meet their specific goal. To maximize resource efficiency, companies should prioritize collecting primary data and using higher quality methods where the biggest impacts and opportunities exist. For the guidelines, the collection of primary data should be prioritized by producers and site owners/operators for sites where conversion-driving commodities are produced (see Annex 1a), land area and volumes of commodities produced.

## 4.5 Data quality

Companies should evaluate quality when considering data collection and selecting data or tools. The principal data and tool criteria to consider include:

- Relevance for application in the methods
- Appropriate spatial and temporal resolution
- Recognition as authoritative and accurate

As previously mentioned, primary data are typically preferred over secondary data. In the case of primary data, these criteria can help guide protocol design to ensure robust data collection and will become more critical when secondary data are required.

When secondary data are employed, these criteria will assist companies in identifying the highest quality data and tools available for their specific purpose. Companies should select the most representative, complete, and reliable data and tools available. Table 5 outlines the data and tool criteria that can be applied to assess quality.

**Table 5 SBTN Data and Tool Criteria (adapted from SBTN, 2023)**

| Characteristic | Description |
|---|---|
| **Relevance** | Appropriate for application in the SBTN methodology and for use in answering the relevant question within the methods |
| **Representative** | Tools and data should represent as close a fit as possible to the context within the SBTN methods. This means for example, where possible data/tools used to estimate impact categories should align with underlying definitions and principles of design in the SBTN methods. In addition, they should be appropriate for application within the geographic, ecological and social context being analyzed. |
| **Spatial and Temporal resolution** | The spatial and temporal resolution of the data used are appropriate to the analysis context and the eventual use in decision making. |
| **Resource Stability and Preservation** | Active effort to maintain a long-term persistence and preservation of datasets (minimum of 5 years after publication) with stable persistent identifiers (e.g. links, DOI etc.). |
| **Accessibility** | Data must be readily accessible online. Free access is preferred, but paid tools are acceptable when they contain data which are uniquely fit for purpose. |
| **Interpretability** | Data/tool outputs are interpretable with sufficient guidance (either in the methods or in the tool) to generate appropriate inputs for use in the SBTN methods. For further guidance on interpretation, end users should first approach the data and tool developers. |
| **Coverage** | Data/tools/approaches should be appropriate for analysis across major subsets of portfolios, corporate footprints etc. Where possible, data should comprehensively cover the spatial context of the assessment, or facilitate harmonization, aggregation or summarization as appropriate to the stage of analysis. |
| **Authoritative and Accurate** | Data are recognized as authoritative and accurate. They have been through a third-party review process, e.g. peer-review in the scientific literature, reviewed by peers in the gray literature, and/or a validation exercise. |

## 4.6 Method selection

As there are multiple quantification methods available to estimate land impacts, companies should assess the advantages and disadvantages when selecting methods. Table 6 provides a summary of the core quantification approaches.

In line with the (draft) GHG Protocol LSRG (2022), when selecting methods companies should consider the following factors:

- Accuracy, continuity, and uncertainty associated with the quantification approach.
- Relevance of quantification approach and methods to the companies' operations and value chain.
- Technical expertise required to implement the quantification approach.
- Available tools and resources to support quantification.
- Secondary data available for activities relevant to the company.
- Primary data requirements for the selected method.
- Consistency across datasets which are being directly compared across time.

**Table 6 Advantages and disadvantages of quantification approaches (adapted from (draft) GHG Protocol, 2022)**

| Quantification approaches | Advantages | Disadvantages |
|---|---|---|
| **Activity-based** | • Simplest methods to apply. | • Often unable to represent specific land management practice changes.<br>• Contains large uncertainty in estimates. |
| **Model-based** | • Able to represent a range of land management practices, depending on model design and calibration.<br>• May cover multiple land impacts. | • Requires detailed technical expertise to implement.<br>• Requires direct measurements to calibrate to site-specific or management specific conditions. |
| **Remote sensing-based** | • Able to represent a range of land management practices, depending on model design and calibration.<br>• Provides spatially explicit estimates that are more geographically representative.<br>• Can improve the accuracy of management activities.<br>• Reduce the cost of data collection. | • Requires detailed technical expertise to implement.<br>• Requires direct measurements to calibrate to site-specific or management-specific conditions. |
| **Measurement-based** | • Able to capture impact of all land management practices. | • In some instances, can be costly and labor intensive.<br>• Requires site specific data collection. |

Data requirements vary by quantification method and can be an important consideration when selecting methods to quantify land impacts ((draft) GHG Protocol, 2022). Table 7 provides an overview of data types needed to estimate land impacts by quantification method.

**Table 7 Examples of data types by quantification method and data type (adapted from (draft) GHG Protocol, 2022)**

| Quantification approaches | Data type | Example activity data and/or inputs |
|---|---|---|
| **Activity-based** | Primary data | • Product quantity or land area by known sourcing areas |
| | Secondary data | • Product quantity by unknown sourcing areas or country of origin |
| **Model-based** | Primary data | • Supplier-specific input data from known sourcing areas |
| | Secondary data | • Input data based on average practices within the country |
| **Remote-sensing based** | Primary data | • Remote sensing data in known sourcing areas |
| | Secondary data | • Remote sensing data from known countries of origin |
| **Measurement-based** | Primary data | • Land use and stratification on known sourcing areas |
| | Secondary data | • N/A (direct measurements always primary data) |

## 4.7 Allocation[3]

In the context of the guidelines, allocation is needed when one system produces several products but land impact data is only quantified for the entire system. In such instances, the total impacts from the common process need to be divided or allocated among the multiple products. Allocation is not necessary if a system produces only one output or impacts from producing each output are separately quantified ((draft) GHG Protocol LSRG, 2022).

Allocation is typically required where co-products are produced e.g. livestock farming for meat and leather, or companies sourcing products that do not have access to sufficient data from the producer or supplier to calculate impacts. Allocation is especially relevant when communicating impacts or emission factors to other actors in the supply chain.

The most appropriate allocation method for a given activity depends on individual circumstances. Different allocation methods may yield significantly different results. Note, specific guidance on allocation for land use change is provided separately in Chapter 5.

[3] **Note for consultation:** this section will need to be reviewed and updated to align with forthcoming guidance from the GHG Protocol LSRG on allocation

In line with the (draft) GHG Protocol LSRG (forthcoming), companies should seek comparable allocation methods with other companies in similar value chains and should ensure that consistent allocation methods are used for each system within a value chain to avoid over- or under-counting of total impacts. The (draft) GHG Protocol LSRG (forthcoming) also provides the following decision tree for companies:

1. Avoid allocation, if possible
2. Align with legislative requirements
3. Align with sectoral recommendations
4. Consider physical allocation (e.g., based on mass, volume, energy content)
5. Consider economic (e.g. based on the market value of co-products) or other allocation (e.g., based on the land area-time needed to produce co-products)

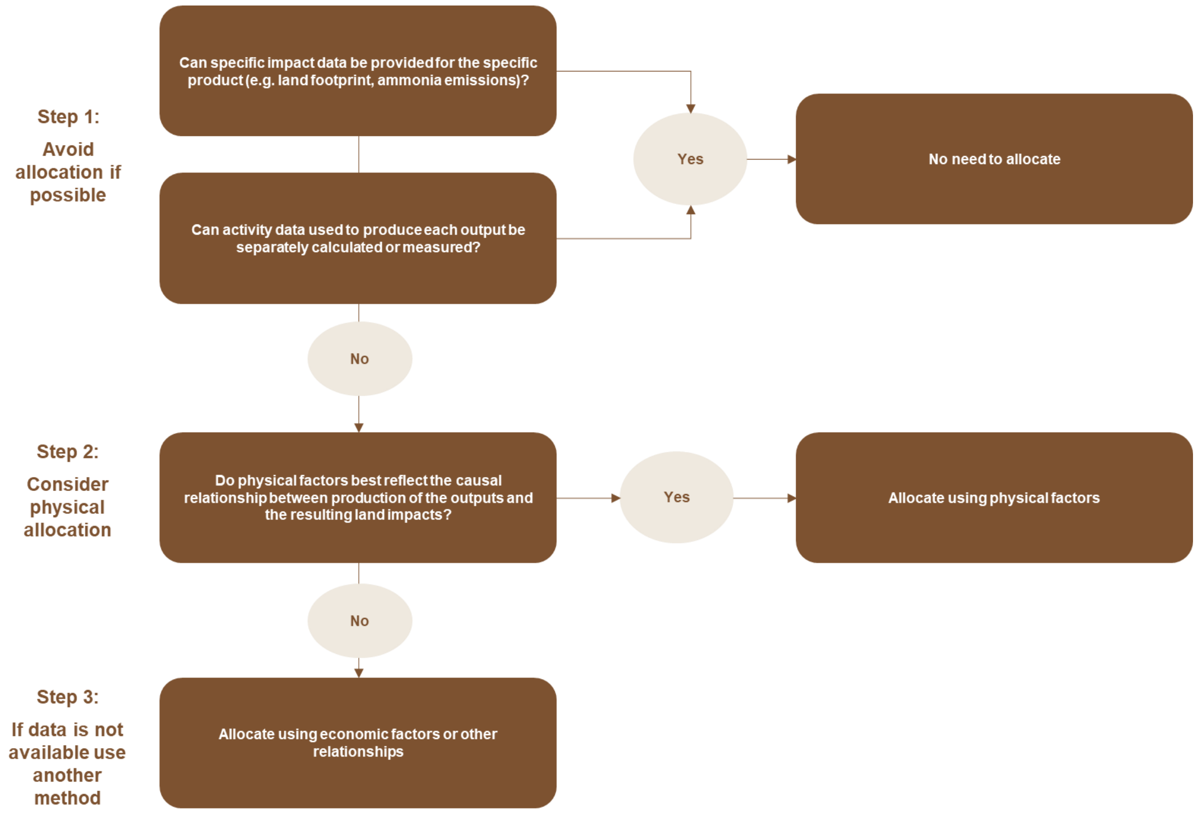



**Figure 5 Decision tree for selecting an allocation approach (adapted from GHG Protocol Scope 3 Standard, 2011)**

Assessing the environmental impacts of products can be a challenge in systems that produce co-products (e.g. intercropping system or meat and leather production system), and impact data is only available and/or quantifiable for the system as a whole. This can lead to inaccurate estimations of environmental impacts associated with each product and make it difficult for companies to make informed decisions to reduce associated pressures on land. These challenges can be overcome by implementing appropriate methods of allocation to partition impacts from a single system among its various outputs.

Companies should avoid or minimize allocation by collecting more detailed data, for example by obtaining product-level impact data from suppliers (GHG Protocol, 2011).

Where allocation cannot be avoided, the inputs and outputs of the system should be partitioned between its different products or functions in a way that reflects the underlying physical relationships between them.

- **Physical allocation** allocates impact to a product based on a physical attribute such as mass, volume, or energy. For example, using physical allocation, if a company purchases 50% of the products produced from a supplier by mass, the purchasing company would allocate 50% of the supplier's impacts in their upstream impact calculation.

| Physical allocation |
| --- |
| *Allocated land impact = (Mass of product purchased (e.g. mass of meat purchased) / total mass of product produced (e.g. total livestock biomass)) x Total land impact* |

Where physical relationship alone cannot be established or used as the basis for allocation, the inputs should be allocated between the products and functions in a way that reflects other relationships between them. For example, input and output data might be allocated between co-products in proportion to the economic value of the products.

- **Economic allocation** attributes impact based on the price of a product relative to the price of all products from a given supplier. For example, if a company purchases 50% of the total market value of all products from a supplier, the purchasing company would be allocated 50% of the supplier's impacts. This method assumes price is a proxy for impact intensity.

  Note: As outlined GHG Protocol, Corporate Value Chain (Scope 3) Accounting and Reporting Standard, companies should use economic allocation with caution as it may yield inaccurate results, particularly when price changes significantly or frequently over time, companies pay different prices or prices are not well-correlated with underlying physical properties and environmental impacts (e.g., for luxury goods, products with high brand value, and products whose price reflects high research and development, marketing or other costs outside of production).

| Economic allocation |
| --- |
| *Allocated land impact = (Market value of product purchased / total market value of product produced) x Total land impact* |

Companies that have a choice between multiple methods of allocation for a given commodity or derived product should evaluate each method to determine the range of possible results before selecting a single method (e.g. by conducting a sensitivity analysis) ((draft) GHG Protocol LSRG, 2022). For more information on physical and economic allocation, please refer to Chapter 8 of the GHG Protocol, Corporate Value Chain (Scope 3) Accounting and Reporting Standard and the (draft) GHG Protocol LSRG (2022).

## 4.8 Recalculating the baseline

Following the (draft) GHG Protocol LSRG (2022), recalculation is required when the following changes occur and have a significant impact on the impact category being calculated:

- Structural changes in the reporting organization, such as mergers, acquisitions, divestments, outsourcing, and insourcing.
- Changes in calculation methods, improvements in data accuracy, or discovery of significant errors.
- Changes in the categories or activities included in the inventory.

For companies using these guidelines to set SBTN Land targets, recalculations must also take place based on any new versions of the Step 3: Land (Version 2.0) technical guidance. In line with current SBTN claims guidance, companies must use the latest version of methods and tools approved by SBTN. Submissions for validation that use previous versions of the tools or methods can only be submitted for validation within 6 months of the publication of the revised method or tool.

## 4.9 Method application and reporting guidelines

Companies should apply the following guidelines to calculate and report land impacts:

- Consistent application of accounting methods for each impact category.
- Report direct operations and upstream value chain impacts separately for each impact category.
- Disclose the data sources, methods, and assumptions used to quantify land impacts.
- For organizational purposes, companies may separate out their impact category reporting by type of land use (e.g., cropland and pastureland), commodities/products produced or sourced, location, ecoregion and/or production unit.
- When defining the spatial boundary for direct operations, define the spatial boundary as lands owned or controlled by the reporting company based on the consolidation approach they have selected.
- When defining the rest of the value chain, define the spatial boundary in line with Table 2 value chain stages relevant to the reporting companies' activities and the company's level of traceability to known lands or regions.

# Chapter 5. Land Use Change

*This chapter provides guidance on accounting for deforestation and conversion, and is structured as follows:*

| Section | Guidelines |
|---|---|
| **5.0** | **Defining land use change** in the context of the guidelines and in alignment with the Accountability Framework initiative and the GHG Protocol |
| **5.1** | **Overview of accounting for conversion of natural ecosystems**<br>• Guidance is differentiated between producers, site owners and operators, and companies sourcing conversion-driving commodities (see Annex 1a) |
| **5.2** | **Set cutoff dates** provides guidance on setting cutoff dates for land conversion |
| **5.3** | **Data requirements** outlines the data requirements for companies at different stages of the value chain covering:<br>• Producers and site owners/operators<br>• Sourcing from producers or first point of aggregation<br>• Sourcing downstream first point of aggregation |
| **5.4** | **Using the SBTN Natural Lands Map** introduces the SBTN Natural Lands Map and provides guidance for using it to account for conversion of natural ecosystems for companies with access to spatial data |
| **5.5** | **Measure and account for conversion of natural ecosystems** for companies with:<br>• Traceability to the production unit level<br>• Traceability to the sourcing area level |
| **5.6** | **Further guidance on statistical approaches to measure and account for conversion of natural ecosystems** |

## 5.0 Defining land use change

For these guidelines, land use change is defined as including conversion and deforestation and uses the following definitions which are adapted from the Accountability Framework initiative (2024b):

**Conversion** is defined as the loss of a natural ecosystem as a result of its replacement with agriculture or another land use, or due to a profound and sustained change in a natural ecosystem's composition, structure or function.

- Deforestation is one form of conversion (conversion of natural forests).
- Conversion includes severe and sustained degradation or the introduction of management practices that result in a profound and sustained change in the ecosystem's composition, structure or function.
- Change to natural ecosystems that meets this definition is considered to be conversion regardless of whether or not it is legal.

| Degradation |
| --- |
| Degradation refers to changes within a natural ecosystem that significantly and negatively affect its composition, structure, and/or function and reduce the ecosystem's capacity to supply products, support biodiversity, and/or deliver ecosystem services. |

**Deforestation** is defined as the loss of natural forest as a result of: (i) conversion to agriculture or other non-forest land use; (ii) conversion to a tree plantation; or (iii) severe and sustained degradation.

- This definition pertains to no-deforestation supply chains that generally focus on preventing the conversion of natural forests.
- Severe and sustained degradation (scenario iii in the definition) constitutes deforestation even if the land is not subsequently used for a non-forest land use.
- Loss of natural forest that meets this definition is considered to be deforestation regardless of whether or not it is legal.
- The Accountability Framework's definition of deforestation signifies 'gross deforestation' of natural forest where 'gross' is used in the sense of "total; aggregate; without deduction for reforestation or other offset".

**Inclusion of waste and residues:** For companies using the guidelines to set an SBTN Land No Conversion of Natural Ecosystems ("No Conversion") target, to identify whether waste and residues from the inputs to, processing, or manufacturing of conversion-driving commodities must be included in scope of the target, companies must follow the below hierarchy. Volumes of waste and residues used in such processes will be included based on:

1. Compliance with existing national or relevant jurisdictional legislation defining what constitute waste and residues

2. Alignment with sectoral best practices on the inclusion of waste and residues

If either option is not clear or available, waste and residue must be included when the product classified as waste and/or residue and has an economic value.

## 5.1 Overview of accounting for conversion of natural ecosystems

Companies using these guidelines to set an SBTN Land No Conversion target need to demonstrate the compliance of conversion-driving commodities with target requirements (e.g., portion of volumes that can be proven to be deforestation-and-conversion free (DCF) by following one of the options available to companies to demonstrate compliance; please see section 1.4 and 1.5 of the (draft) Step 3: Land technical guidance.

For volumes of conversion-driving commodities whose DCF status is unknown, companies will measure and account for land use change by following the guidelines outlined in this Chapter adapted from the Accountability Framework initiative's guidance on the topic in Section 5.5 *Measure and account for conversion of natural ecosystems.*

These guidelines are structured based on a company's position within the value chain - separated into producers, site owners and site operators, and sourcing of goods or services that lead to natural ecosystem conversion (conversion-driving commodities, listed in Annex 1a).

In order to calculate the baseline, producers, site owners, and site operators:

- Map production units (and other operational areas) and locate them within the Natural Lands Map.
- Account for conversion of natural ecosystems at the level of production unit that occurred after the cutoff date(s), using land cover change data from the cutoff year to target setting date (year 0), consulting the Natural Lands Map to see if land cover change occurred on natural lands.

Those engaged in sourcing conversion-driving commodities:

- Map the value chain and identify the origin of volumes of all material conversion-driving commodities (Annex 1a) to the production unit or sourcing area.
    - Disaggregate volumes per commodity and per traceability level and link to production unit, sourcing area/ subnational level of origin.
- Account for the percentage of commodity volumes in compliance with deforestation and conversion-free requirements.
- Calculate the percentage of commodity volumes in compliance with deforestation-and conversion-free requirements.
- For volumes that are not yet traceable to a production unit or sourcing area, engage the supply chain to enhance traceability and increase the percentage of volumes in compliance with deforestation- and conversion-free requirements in line with traceability requirements (see section 1 of the (draft) Step 3: Land (Version 2.0) technical guidance).

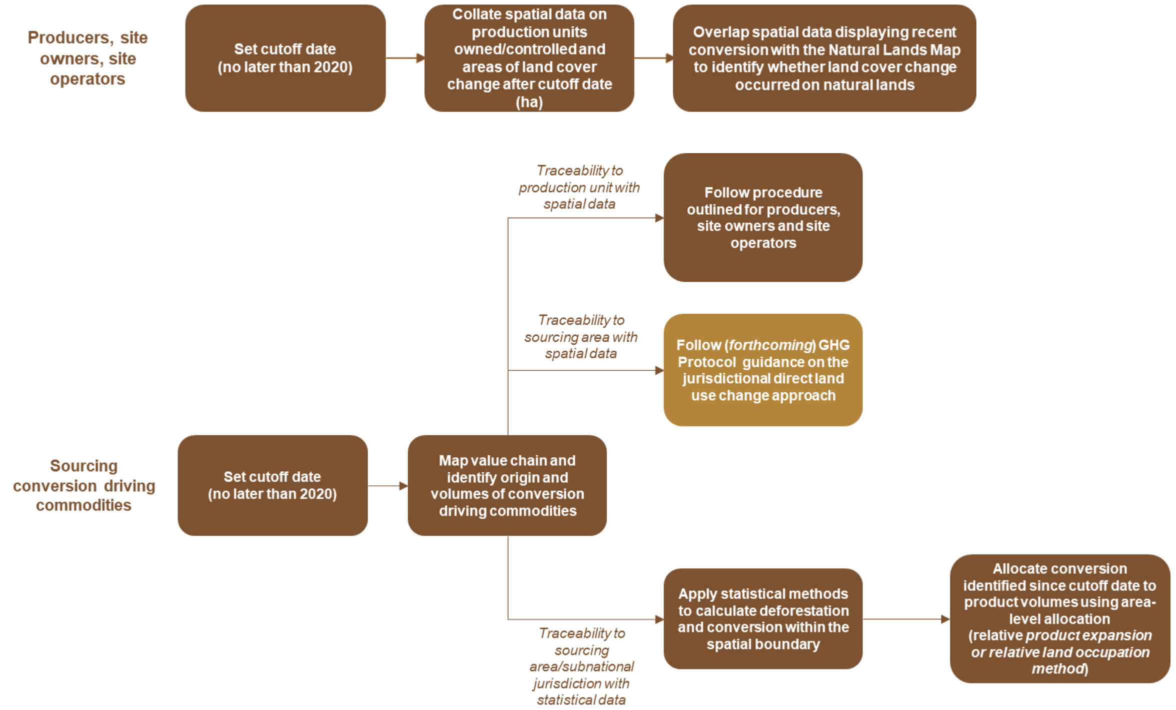



**Figure 6 Overview of steps to calculate conversion of natural ecosystems for producers, site owners and site operators and companies sourcing conversion driving commodities**

## 5.2 Set cutoff dates

To assess whether land conversion has occurred, land use change events are considered over an assessment period lasting from a cutoff date until the present. For companies setting an SBTN Land No Conversion target the cutoff date provides a baseline; after this date, any conversion of natural ecosystems on a given production unit renders the materials produced on that production unit non-compliant with an SBTN Land No Conversion target.

Companies setting an SBTN Land No Conversion target *must* use cutoff dates no later than 2020 as the reference for assessing conversion of natural ecosystems (forests and non-forests). Where other cutoff dates earlier than 2020 exist, companies should use those earlier dates. Companies that have already set a cutoff date earlier than 2020 must use that earlier date or provide justification to SBTN for changing it.

*As recommended by the Accountability Framework initiative (2022, 2023), cutoff dates should align with existing sectoral or regional cutoff dates where they exist, such as the Amazon Soy Moratorium, and cutoff dates associated with certification should not be later than 2020.*

| **Cutoff dates versus assessment period** |
| --- |
| Land use change emissions accounting and target setting (guided by the GHG Protocol and SBTi FLAG, respectively) requires companies to measure land use change and corresponding emissions based on a retrospective assessment period of 20 years or longer, starting from the reporting year and looking back in time.<br><br>If products have a crop cycle or rotation period greater than 20 years, then the assessment period should be at least as long as the crop rotation period. The length of the assessment period reflects the average time that it takes for soil carbon stocks to reach a new equilibrium following land use or conversion and takes into consideration diverse land use change trajectories.<br><br>The GHG Protocol and SBTi FLAG guidance allows for flexibility in the approach used to allocate the total land use change emissions over the assessment period. Specifically, companies may choose to apply either linear discounting or equal discounting over time. See the (draft) GHG Protocol LSRG (2022) for more detail.<br><br>The longer time frame included in land use change emissions for GHG accounting is based on how long emissions from ecosystem conversion remain in the global emissions budget. However, this calculation does not provide guidance on when that land conversion should stop, only the length of time that emissions must be reflected in the GHG inventory.<br><br>The 2020 cutoff in the guidelines and the SBTN Land No Conversion target acts independently of this GHG accounting guidance and provide a cutoff date for conversion of natural ecosystems aligned with the Kunming-Montreal Global Biodiversity Framework. |

## 5.3 Data requirements

To account for conversion of natural ecosystems, companies need to collect data on:

- Location and delineated area of production units of conversion-driving commodities that they own or manage (see definitions for ownership in SBTN Step 1 methods and conversion-driving commodities in Annex 1a).
- Operational site areas (e.g., farms, mines, retail locations, infrastructure, and construction sites) that they own or manage.
- Geographic origin and volumes of conversion-driving commodities in their supply chains at the production unit level or sourcing area level.
    - When the origin of all commodities is not yet known at this scale, companies must disclose the volumes of each commodity that is known only at the resolution of the country level. Companies must also disclose the volumes of each commodity that is of unknown origin. For companies setting an SBTN Land No Conversion target, include these volumes in target boundary B as per SBTN Step 2 requirements.
- For producers, site owners, site operators, and companies sourcing raw conversion-driving commodities from producers or from first point of aggregation as well as those sourcing downstream of the first point of aggregation: the amount of natural ecosystem conversion that occurred after the company's cutoff date on sites it owns or manages, on production units known to be in its supply chains, or in sourcing areas from which it sources commodity volumes.
- Note, for companies setting an SBTN Land No Conversion target, data structure needed requires traceability of conversion-driving commodities at least to subnational jurisdiction.

**Detailed data requirements for producers, site owners and site operators**

- All production units and operational sites demarcated by georeferenced boundaries (i.e., polygons), with the exception of small sites (less than 10 ha), for which one point coordinate near the center of production is sufficient.
- Around this point coordinate, a circular buffer with a 12.75-ha area (200 m radius) must be drawn to identify potential conversion occurring within the buffer. Should conversion events be detected in this buffer area, further assessment will be required to identify the real extent of conversion linked to direct operations of the company.
- Companies are required to account for conversion post cutoff date(s) for their direct operations.

**Detailed data requirements for companies sourcing conversion-driving commodities**

- Volumes of conversion-driving commodities (Annex 1a):
  - Disaggregated volumes per commodity and per traceability level and linked to production unit, sourcing area level of origin.
  - Volumes that cannot be traced at least to subnational level.

AND/OR

- Volumes physically certified using a scheme that delivers no-conversion assurance based on physical chain of custody systems.

| Certification schemes |
| --- |
| For companies setting an SBTN Land No Conversion target, the use of certification schemes will depend on the ability of a scheme to provide evidence that the certification scheme, through a chain of custody system, demonstrates both deforestation and conversion-free with reasonable assurance.<br><br>To date, it is not possible for SBTN to evaluate and approve any of the variety of certification schemes that may or may not provide such assurance. As such, companies wishing to use certifications as proof of no conversion (including deforestation free) must submit this evidence to SBTN as part of the target validation process.<br><br>Preliminary guidance for certifications that demonstrate such assurance for deforestation-free and conversion-free assessments has been provided in the Accountability Framework Initiative and CDP (2024) Time for Transparency report. It is expected that certification schemes will evolve over time in alignment with SBTN standards and regulatory drivers as adoption increases. |

For companies using these guidelines to set an SBTN Land No Conversion target, please refer to the (draft) Step 3: Land (Version 2.0) technical guidance on how to assess compliance with target requirements by target dates.

Table 8 summarizes the data needs for accounting for conversion of natural ecosystems.

**Table 8 Specific data needs for calculating conversion of natural ecosystems**

| Requirement | Stage of the value chain | Data type | Unit | **Spatial data requirements** (Georeferenced polygons of production units or sourcing areas) |
|---|---|---|---|---|
| **Required** | **Producers and site owners/operators** | Location of all sites where conversion-driving commodities are produced | Hectares | Required |
| | | Areas converted after cutoff date | Hectares | Required |
| | **Sourcing from producers or first point of aggregation** | Sourcing area and volumes of conversion-driving commodities purchased | Hectares and metric tons or equivalent from each area | Recommended |
| | **Sourcing downstream from first point of aggregation** | Sourcing area and volumes of conversion-driving commodities purchased | Hectares and metric tons or equivalent from each area | Recommended |
| **Recommended** | **Sourcing from producers or first point of aggregation** | Production unit | Hectares | Recommended |
| | **Sourcing downstream from first point of aggregation** | Production unit | Hectares | Recommended |

## 5.4 Using the SBTN Natural Lands Map

The SBTN Natural Lands Map is used to:

- Estimate natural ecosystem conversion since 2020 that is associated with the company's operations or commodity volumes in its supply chains.
- Provide the data necessary for companies to operationalize a 2020 cutoff for no-conversion calculations.

Note, the SBTN Natural Lands Map can only be used for 2020 cutoff dates. Where other cutoff dates earlier than 2020 exist, companies should use those earlier dates. Companies that have already set a cutoff date earlier than 2020 must use that earlier date or provide justification to SBTN for changing it.

Details on how to access and use the SBTN Natural Lands Map are included in Annex 1c.

In this process, preventing the conversion of natural ecosystems starts with defining natural lands and estimating where they exist by delineating them on a map.

Natural ecosystems are defined in line with the Accountability Framework initiative's definition of a natural ecosystem as "one that substantially resembles—in terms of species composition, structure, and ecological function—what would be found in a given area in the absence of major human impacts" and can include managed ecosystems as well as degraded ecosystems that are expected to regenerate either naturally or through management (Accountability Framework Initiative, 2024). According to this definition, SBTN maintains that natural ecosystems include:

- Largely "pristine" natural ecosystems that have not been subject to major human impacts in recent history.
- Regenerated natural ecosystems that were subject to major impacts in the past (for instance by agriculture, livestock raising, tree plantations, or intensive logging) but where the main causes of impact have ceased or diminished, and the ecosystem has attained species composition, structure, and ecological function similar to prior or other contemporary natural ecosystems.
- Managed natural ecosystems (including many ecosystems that could be referred to as "semi-natural") where much of the ecosystem's composition, structure, and ecological function are present; this includes managed natural forests as well as native grasslands or rangelands that are, or have historically been, grazed by livestock.
- Natural ecosystems that have been partially degraded by anthropogenic or natural causes (e.g., harvesting, fire, climate change, invasive species, or others) but where the land has not been converted to another use and where much of the ecosystem's composition, structure, and ecological function remain present or are expected to regenerate naturally or by management for ecological restoration.

While natural forests are of course part of natural ecosystems, a detailed forest definition is also provided by the Accountability Framework initiative:

- Forests are defined as "land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds *in situ*. It does not include land that is predominantly under agricultural or other land use" (Accountability Framework Initiative, 2024).

- Natural forests are defined as possessing “many or most of the characteristics of a forest native to the given site, including species composition, structure, and ecological function.”

Natural forests include primary forest, regenerated second-growth forests, managed natural forests, and forests that have been partially degraded but still retain their composition, structure, and ecological function or are expected to regenerate naturally or by management for ecological restoration. Natural forest and tree plantations are mutually exclusive (Accountability Framework initiative, 2024).

The Accountability Framework initiative’s conversion definition is used also in anticipation of utilizing the SBTN Natural Lands Map as a baseline for future monitoring purposes, which includes a change to another land use or profound change to composition, structure, or function (Accountability Framework initiative, 2024). Such changes are considered ecosystem conversion regardless of whether or not the change was legal.

In the context of these guidelines, the SBTN Natural Lands Map is not intended to:

- Contain time-series data that may be useful for monitoring conversion.
- Quantify the area of natural and non-natural lands because of known overestimation of natural lands.
- Supplant existing research and biophysical mapping and analysis on ecosystem science.
- Define ecosystems and/or working lands.
- Be used to assess the quality of ecosystems, including value for biodiversity.
- Represent an unbiased map of natural lands - the conservative approach used overestimates the extent of natural lands, and while remote sensing data, on which the map is based, can provide powerful insights, additional field work should be used to check/confirm the accuracy of the map and to understand local dynamics.

This map demonstrates a conservative approach to mapping non-natural lands, meaning that decisions were made with the aim of being precautionary in assigning a non-natural classification. As a result of the conservative approach, the final dataset may overestimate the area of natural lands in some regions.

**To develop this map, the approach for identifying natural lands across the globe has been to combine the best available global spatial data on land cover/land use into a single harmonized map at a 30-meter resolution**. The land cover data that were best for distinguishing between natural and non-natural land covers have been assessed and selected, using additional data where necessary (see: technical documentation of Natural Lands Map).

Where available, regional data from 2020 were incorporated and prioritized to ensure that local and regional knowledge is best reflected in the map.

When using these guidelines, if it becomes clear that the representation of natural or non-natural land indicated by the SBTN Natural Lands Map is inconsistent with local realities please contact SBTN.

The Accountability Framework Initiative’s definition of natural ecosystems has been operationalized to natural lands based on existing land cover/land use data in the SBTN Natural Lands Map. Table 1 in the technical documentation of the map shows the Accountability Framework initiative’s operational guidance and describes how it was used to develop the mapping approach. Table 8 in the technical documentation shows the final map classes and their definition, as not all parts of the Accountability Framework initiative definitions are currently mappable. Specific data and methods used are described in Section 2.2 and 2.3 of the technical documentation.

In the absence of specific definitions for ecosystems outside of forests from the Accountability Framework initiative, the SBTN Natural Lands Map is built on other definitions from available data. Here, natural grasslands are defined by identifying short vegetation (<5 meters) that are not cultivated, cropland, or tree crops using Land and Carbon Lab's Global Pasture Watch (GPW). Cultivated grasslands are areas where grasses and other forage plants have been intentionally planted and are actively managed as well as areas of heavy management for human-directed uses such as grazing livestock.

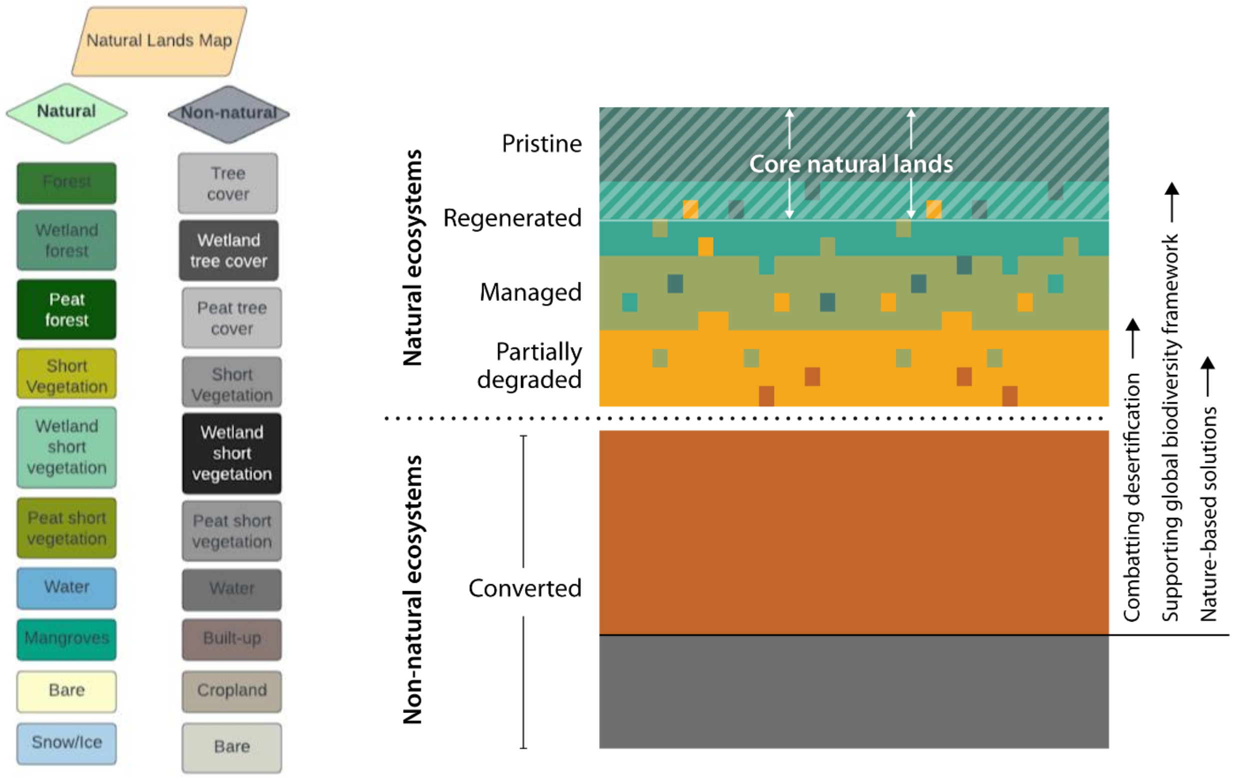



**Figure 7 Land-cover classes of the SBTN Natural Lands Map and the classification categories of natural ecosystems.**

*Note: This figure outlines the range of what is considered "natural" for inclusion in the SBTN Natural Lands Map. Core natural lands are a priority designation within natural lands. Here they are indicated as primarily pristine or regenerated ecosystems, though the data in the Map may identify core natural lands within managed or partially degraded ecosystems as well.*

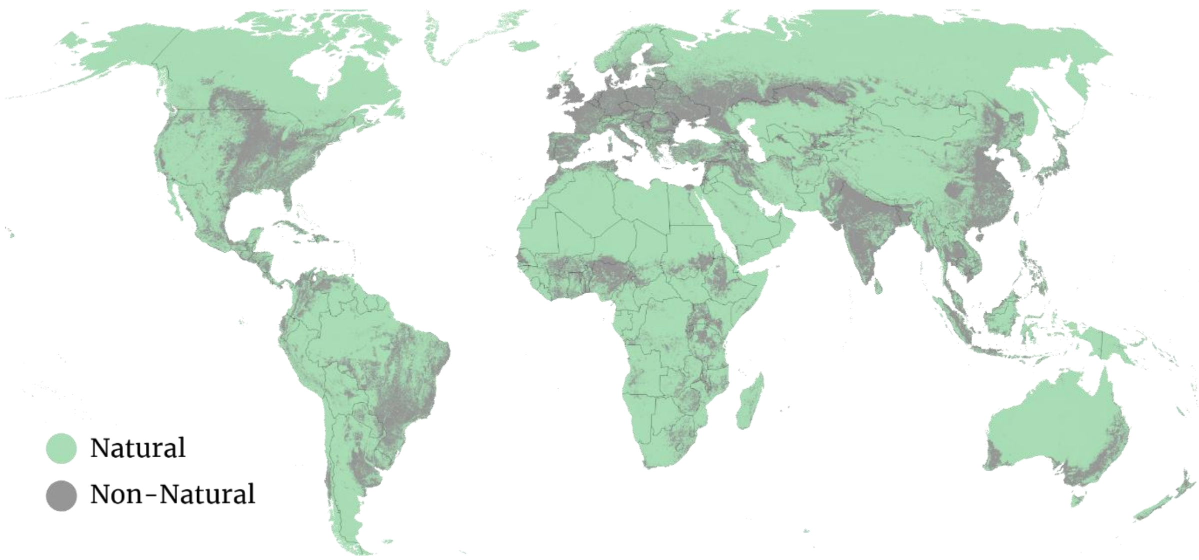



**Figure 8 Natural Lands Map**

*Note: There is no data on the glaciers of Greenland. The global scale of the map obscures data at a smaller scale, meaning that areas that look entirely natural or non-natural at the global level will likely have significantly more diversity in classification at a 30-meter resolution of the map. View and interact with the SBTN Natural Lands Map: [https://wri-datalab.earthengine.app/view/sbtn-natural-lands](https://wri-datalab.earthengine.app/view/sbtn-natural-lands)* ***Technical documentation***

**Table 9 Examples of ecosystem types that may be included under the map's natural land-cover classes**[4]

| Natural land-cover class | Class definition | Ecosystem examples |
|---|---|---|
| **Forest** | Areas with tree cover greater than or equal to 5 meters in height spanning more than 0.5 hectares, excluding planted trees | Rainforests, dry forests, montane rainforests, heath forests, temperate forests, boreal forests, woodlands, some types of savannas. |
| **Short vegetation** | Areas of land with vegetation shorter than 5 meters, including areas of land dominated by grass or shrubs, but excluding areas with cultivated grasslands | Grasslands, shrublands, heathlands, steppes, vegetated deserts and semi-deserts, some types of savannas. |
| **Wetlands** | Transitional ecosystems with saturated soil that can be inundated by water either seasonally or permanently and can be covered by short vegetation or trees. | Peatlands, mangroves, inland, coastal, saline, freshwater, brackish. |
| **Water** | Surface water present 20% or more of the year, where water is the dominant class. | Rivers, lakes, coastal inlets, bays, lagoons. |
| **Snow/ice** | Areas covered by permanent snow or ice. | Glaciers, perennial snowfields. |
| **Bare land** | Areas with exposed rock, soil, or sand with less than 10% vegetated cover. | Sparsely vegetated deserts, lava flows, screes, alpine rocky outcrops, sandy shorelines. |

*Note: The ecosystem examples included in this table are not an exhaustive list of all ecosystems included within each land-cover class but are illustrative examples of some types of ecosystems that may be included. Land-cover classes are defined based on the biophysical presence and coverage of certain types of vegetation or landforms, and thus a similar type of ecosystem in different regions may fall into different land-cover classes depending on the biophysical characteristics present. In cases where local data was incorporated, we adopted the local definition of the land cover; therefore, there may be inconsistencies in how land-cover classes are defined (e.g., tree height threshold for forests).*

## 5.5 Measure and account for conversion of natural ecosystems

This section provides guidance on how companies must or should account for conversion.

The following guidelines are informed by the Accountability Framework initiative's guidance and adapted to the scope of the guidelines.

The term "land use change" (LUC) is kept here in alignment with the GHG Protocol's accounting guidance but is synonymous with "conversion" and "terrestrial ecosystem change."

To effectively progress toward the achievement of targets to end deforestation and conversion from operations and supply chains, companies *must* measure and account for land use change in credible and consistent ways. This process is also key to accounting for land use change emissions in setting SBTi FLAG targets. After completing

[4] For a full description of land cover classes, please see Table 8 in the technical documentation of the Map

the accounting exercise, companies will then use the SBTN Natural Lands Map to understand which portion of land use change constitutes conversion of natural ecosystems.

SBTN recommends that companies account for conversion on an annual basis to demonstrate either compliance with target requirements or to understand the exposure to conversion or conversion risk associated with their sourcing from a given area. Companies should not allocate conversion from a year for which the company does not yet have supply chain data. For instance, if the company has supply chain information on sourced volumes up to 2021, then only conversion between 2020 and 2021 should be allocated to those volumes if the company has used 2020 as the cutoff date. Further guidance on measuring and accounting for conversion is provided in section 5.6 for companies that do not have sufficient data to calculate conversion associated with sourcing on an annual basis.

Companies can account for conversion using two methods that are outlined in the following sections:

- Assessment at the production unit level, which requires full traceability and spatial data.
- Assessment at the sourcing area level, which requires traceability to at least the subnational level.

### 5.5.1 Land use change – scale

Land use change *may* be assessed based on production unit-level information for direct operations and/or estimated based on the attribution of land use change occurring at the level of the sourcing area for upstream activities. The parallel processes for calculating land use change emissions are called direct (dLUC) and statistical land use change (sLUC), respectively (see the (draft) GHG Protocol LSRG (2022) for further information).

*Note, there are two additional approaches for calculating land use change emissions at the level of the sourcing area, the jurisdictional dLUC (jdLUC) and spatial sLUC approach, provided in the (draft) GHG Protocol LSRG (forthcoming). Companies with the requisite data that are assessing land use change at the sourcing area level can alternatively follow these approaches in line with the forthcoming GHG Protocol LSRG. Companies will need to adapt these methods to calculate the area of conversion attributable to their sourcing to align with SBTN requirements.*

The determination of the appropriate scale of analysis will largely depend on the ability of the company to trace products through the supply chain to their origin, as well as the extent to which that origin is associated with risk of deforestation or ecosystem conversion and the appropriate scale of management given the context of production and sourcing.

The guidelines recognize that full traceability to production units is not always available, and that in some contexts a sourcing area or jurisdiction may be the most relevant scale for managing land use change risks. As such, the guidelines provide methods for estimating land use change at an area level.

There are three primary scales at which land use change can be assessed:

1) **Traceability to the production unit of origin**
    - This means that companies can trace commodity volumes to specific mapped production units (e.g., farms, ranches, mines, fields, plantations and forest management units).

- The Accountability Framework initiative defines a production unit as a discrete land area on which a producer cultivates crops, manages timber, or raises livestock. In the context of this guidance, the understanding of production units is expanded to the extraction sites of hard commodities listed in Annex 1a (see Chapter 3 for definition of production unit).

2) **Traceability to the sourcing area**
   - This means that products are traceable to a known area or region where the material was produced or extracted, but that the specific production unit of origin is not known.
   - Sourcing area-level boundaries could include a sourcing radius from a first point of collection or processing facility (e.g. a radius from an oil palm mill), a defined production landscape (e.g. the area covered by a smallholder cooperative), or a subnational jurisdiction (e.g. municipality).

3) **Limited or no current traceability**
   - This means that products can currently only be traced to a country of origin or that the origin of products is unknown.
   - Companies setting an SBTN Land No Conversion target should place these products in target boundary B.

**Table 10 Appropriate measures of land use change**

| Level of traceability and monitoring | Position in the supply chain | Unit of analysis | Accounting metrics and methods for deforestation and conversion (disaggregated by commodity) |
|---|---|---|---|
| **Production unit** | Own operations | Own farms and/or plantations | • Hectares of deforestation or conversion in operations since cutoff date<br>• % of total hectares owned or managed that this represents |
| | Supply chain | Known supply chain farms/plantations | • Hectares of deforestation or conversion on production units in supply chain since cutoff date<br>• % of total hectares on known farms that this represents |
| **Sourcing area** | Supply chain | Known sourcing (e.g., mill sourcing radius, production landscapes, or subnational jurisdictions) | • Hectares of natural ecosystem conversion in sourcing areas since cutoff date that may be attributed to the company |
| **Limited or no traceability** | Supply chain | Country of origin | • Volume of materials (and proportion of total) sourced from each country* |
| **Limited or no traceability** | Supply chain | Unknown origin | • Volume of materials (and proportion of total) sourced for which region is unknown* |

*Where there is limited to no traceability, hectares of deforestation and conversion cannot be estimated. Source: Accountability Framework initiative (2022)

#### 5.5.1.1 Land use change – at production unit level

Monitoring conversion at the level of production units (e.g., farms, plantations, and forest management units) provides the greatest amount of precision about the impact of company operations and supply chains and is the best way to determine whether products or sites are linked to recent deforestation or conversion.

When accounting for deforestation and conversion at the site level, all conversion in the production unit that has occurred since the cutoff date must be included, regardless of the current use of that land (i.e., whether it is used to produce the commodity of interest, to produce another commodity, has not yet been used to produce a commodity, or is not currently being used for production).

Accounting for land use change at the production unit level requires known and mapped locations of the given production units. Production units should be demarcated by georeferenced boundaries (i.e., polygons), with the exception of small sites (e.g., less than 10 ha), for which one point coordinate at the geographic center of the production and a circular buffer around the point that represents 10 hectares will be sufficient. The same approach explained for production units can be used for project sites (e.g., mining sites and construction sites).

The role of any given company in monitoring and accounting for land use change at the production unit level may differ depending on its position(s) in the supply chain.

- **Upstream supply chain actors** (i.e., producers, primary processors, and traders with visibility to the production unit) are in a position to monitor on-the-ground conditions. They should directly monitor and document land use change and furnish downstream buyers with information about deforestation and conversion associated with the products being sold.
- **Downstream companies** that purchase commodities or derived products may assess recent deforestation and conversion at the production unit level by gathering data collected by their suppliers, monitoring known production units directly using spatially explicit remote sensing data, or using third-party certification schemes with chain of custody models that provide traceability to origin.

| **Companies should apply the following steps to account for land use change at the scale of the production unit** |
| --- |
| 1. Identify the spatial boundaries of production units owned or managed by the company or known to produce materials in a company's supply chain using spatial data as outlined in Section 5.3 and 5.5.1.1. |
| 2. Identify land cover change that has occurred within the spatial boundary since the cutoff date. For 2020 cutoff dates, companies may use the SBTN Natural Lands Map to identify whether land cover change occurred on natural lands. Deforestation and conversion identified since the cutoff date should be reported through appropriate indicators (see (draft) Step 3: Land (Version 2.0) technical guidance). |
| 3. If there has been no deforestation or conversion on a production unit since the cutoff date, then product volumes from that production unit may be considered deforestation/conversion-free. |

#### 5.5.1.2 Land use change—at sourcing area level

It is sometimes not possible or appropriate to assess conversion of natural ecosystems at the scale of specific production units in a company's supply chain. In these cases, supply chain deforestation/conversion may be accounted for at the scale of a sourcing area in which production units are located.

Depending on the location, production context, and commodity, a sourcing area may be the supply-shed of a processing facility (such as a radius surrounding a palm oil mill), a production landscape (such as the area encompassing a smallholder cooperative), or a subnational jurisdiction.

Assessments at an area level serve as a proxy for direct land use change. By providing an estimate of land use change potentially allocated to a given product, sLUC inherently also considers some amount of indirect land use change, that is, pressure by expansion of one commodity that may lead to land use change for another commodity (see section 4.5 of the Accountability Framework initiative's (2022) guidance).

##### When land use change may be assessed at the level of a sourcing area

Accounting for deforestation and conversion associated with commodities at the scale of a sourcing area may be appropriate in a range of circumstances, including when:

- Downstream companies do not have physical traceability to the production unit level and may therefore need to monitor land use change at the sourcing area level as the best available option. In this case, the sourcing area should be the smallest geographic area from which commodity volume is known to originate, and companies should also take steps to increase traceability of these volumes.
- A sourcing area is the most relevant scale for managing deforestation and conversion risk, for example where:
  - Upstream companies such as primary processors source commodity volumes from a specified radius or source-shed around their facilities without maintaining long-term buying relationships with specific producers.
  - Companies source from smallholder producers whose materials are aggregated at the level of a co-op or collection point and where further traceability is not possible.
- Companies source from jurisdictions or landscapes where it can be shown that there has been no or negligible recent conversion. In these cases, companies may find it cost-effective to monitor deforestation/conversion at the level of such areas. Doing so requires regular monitoring to assess or confirm the risk status of these jurisdictions and identify any changes in risk status

### Methods to allocate land use change in a sourcing area to commodity volumes

There are many approaches to allocating area-level data on land use change to commodity volumes sourced from that area, and improved data and methodologies are rapidly being developed. All such methods utilize remote sensing data repeated over the relevant time frames as well as statistics about production and land use in the area.

### Land use change included in the allocation process

When allocating land use change at an area level to specific commodity volumes, all land use change related to agriculture (for crop or livestock products), forestry (for forest products), and hard commodities for relevant sectors must be included in the analysis. Consideration of all commodity-related land use change allows companies and others to best account for varied land use change trajectories or indirect land use change pressures, providing an appropriately conservative approach to allocation

### Timeframe of land use change included in the allocation process

When accounting for deforestation and conversion, the cutoff date should be used to calculate the land use change to be allocated as outlined in section 5.2.

### Allocation approaches

The GHG Protocol provides two approaches for allocating land use change in a given area:

- Allocation based on product expansion.
- Allocation based on land occupation.

The table below provides a summary description of these two approaches.

**Table 11 Adapted (draft) GHG Protocol LSRG approaches to allocation of land use change at the level of a sourcing area**

| Basis for allocation | Method | Data needs specific to allocation approach | Data needs common to both allocation approaches |
|---|---|---|---|
| **Relative product expansion**<br>***Called 'product expansion approach' by GHG Protocol*** | Allocate recent land use change across products based on the relative area of expansion for each product | Total area of expansion of production in the jurisdiction since cutoff date<br>Expansion of production area of commodity of interest since cutoff date | Area of land use change in sourcing area<br>• Deforestation/conversion occurred since cutoff date<br>Quantity of commodity of interest produced in the area<br>Quantity of commodity of interest sourced by the company from the area |
| **Relative land occupation**<br>***Called 'shared responsibility approach' by GHG Protocol*** | Allocate recent land use change across products based on the relative land area occupied by each product | Total land area in sourcing area<br>Amount of land area in production for commodity of interest in sourcing area | |

Other allocation methods may be used if they meet the above criterion of considering all agricultural, forestry, hard commodity- related land use change in the sourcing area. In particular, when commodities are a relatively small component of land use in an area, other more context-specific approaches may be warranted.

Allocation approaches based on product-specific conversion—those which only consider land use change on land currently used for the production of a given commodity—may not effectively account for land use change trajectories in a sourcing area and therefore may not be credible. Such methods may be assessed through the piloting process of the (draft) GHG Protocol LSRG (2022), and determination of whether this approach (spatial sLUC approach) will be acceptable for land use change emissions accounting will be made following that period.

As noted in Section 5.5.1, an additional approach is being considered as part of the (draft) GHG Protocol LSRG (forthcoming) – the jurisdictional or jdLUC approach. The jdLUC approach reflects an intermediate level of accuracy and accounts for land use change on attributable productive lands in a jurisdiction or sourcing region. The jdLUC approach can be used where companies have spatial data on products sourced at the relevant sourcing area.

In all cases, the method and data sources used to allocate land use change to products within a sourcing area *must* be clearly disclosed as forest or non-forest conversion and ideally disaggregated by ecosystem where possible using the IUCN Global Ecosystem Typology .

| **Companies should apply the following steps to account for land use change at the level of a sourcing area** |
| --- |
| 1. Select an appropriate spatial boundary based on physical traceability of the product to a given area, for example a sourcing region or subnational jurisdiction.<br>*Note, companies setting SBTN Land targets must use the first administrative division below the national scale or better spatial resolution.* |
| 2. To account for deforestation and conversion, use suitable data products to identify all areas within the spatial boundary where land use has changed from a natural ecosystem since the cutoff date. |
| 3. Allocate deforestation and conversion identified since the cutoff date to product volumes using one of the approaches referenced in Table 11 or a similar credible method.<br><br>Deforestation/conversion footprint should be reported through appropriate indicators (see section 1 of the (draft) Step 3: Land (Version 2.0) technical guidance), along with information on allocation methods and data sources.<br><br>If no land use change is identified within a given sourcing area, then volumes sourced from that area may be considered deforestation/conversion-free (see section 4.6 of Accountability Framework initiative's (2022) guidance: *Deforestation- and conversion-free supply chains and land use change emissions: A guide to aligning corporate targets, accounting, and disclosure*). |

## 5.6 Further guidance on statistical approaches to measure and account for conversion of natural ecosystems

For companies adopting the sLUC approach, in order to appropriately account for conversion attributable to sourced commodities, the following data is required:

- Annual supply chain data
- Annual dataset to identify all areas within the spatial boundary where land use has changed from a natural ecosystem
- Ability to allocate deforestation and conversion to a given commodity in a given sourcing area on an annual basis

Without these data, a number of challenges arise which may lead to significant over- and/or under-estimation of conversion attributable to a company's sourcing.

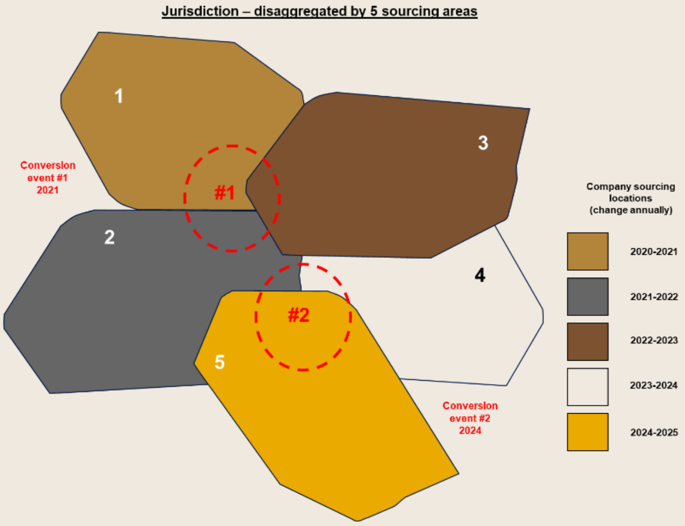
An example is provided below that illustrates some of the challenges companies may face using the sLUC method without annual data.

When assessing conversion using statistical data, if companies cannot calculate attributable conversion annually, SBTN recommends companies calculate the total volumes of sourced conversion-driving commodities and identify conversion events that occurred within the sourcing jurisdiction. Some of this land use change may not be attributable to their sourced volumes and as such companies may disclose that volumes are sourced from jurisdictions 'at-risk of deforestation and conversion'.

**Example**

A company sources conversion-driving commodities and has traceability to the sourcing-area. The company changes its sourcing area on an annual basis as illustrated in the figure below. There have been two conversion events in the jurisdiction in 2021 and 2024. Based on the company's sourcing, attributable conversion to the sourced commodity is:

- Portion of conversion event #1 in Area 2
- Portion of conversion event #2 in Area 5




Two scenarios are provided below that demonstrate the challenges of calculating conversion without annual data.

__Scenario 1__

**Method:** The company assesses conversion in 2025 using supply chain data from 2022 to 2023, and land use change data from 2020 to 2023.

**Calculated conversion:** Volumes sourced from Area 3 are associated with portion of conversion event #1 in Area 3.

**Result:** Incorrect calculation (portion of conversion event #1 in Area 3 not attributable to company).

__Scenario 2__

**Method:** The company performs the assessment in 2025 using supply chain data from 2021 to 2022 and from 2024 to 2025, and land use change data from 2020 to 2025.

**Calculated conversion:** Volumes sourced from Area 2 linked with both conversion events #1 and #2. The volumes sourced from Area 5 are associated with the conversion event #2.

**Result:** Overestimation of conversion (portion of conversion event #2 in Area 2 not attributable to company sourcing).

__Scenario 3__

**Method:** The company assesses conversion using annual supply chain data from 2020 to 2025, and land use change data from 2020 to 2025.

**Calculated conversion:** Volumes sourced from Area 2 are associated with portion of conversion event #1 and volumes sourced from Area 5 are associated with portion of conversion event #2.

**Result:** Correct calculation.

# Chapter 6. Land Area and Quality

*Land quality impacts can arise from anthropogenic activities on land. Land management practices, including the use of forest lands, croplands and grasslands, play a crucial role in shaping the health of ecosystems. Depending on the land management type and intensity, adverse environmental impacts can occur such as depletion of soil carbon, increased soil erosion and soil pollution. These changes can affect biodiversity, soil health and the resilience of ecosystems. Sustainable land management approaches are integral to support future ecosystem health and resilience. This chapter focuses on the provision of accounting guidelines for companies to calculate the following land area and quality categories related to the SBTN Working Land Regeneration and Restoration target:*

- *Land area*
  - *Land footprint*
  - *Natural land cover*
- *Land quality*
  - *Soil organic carbon*
  - *Soil erosion*
  - *Terrestrial acidification*

*An overview of the chapter structure is provided on the table below.*

| Section | Guidelines |
| --- | --- |
| **6.0** | • **Land area and quality impact categories** provides a summary description of each of the land area and quality categories: Land footprint; Natural land cover; Soil organic carbo; Soil erosion; Terrestrial acidification |
| **6.1** | • **Calculation guidelines for land footprint** provides the accounting and calculation guidelines for land footprint for producers, site owners and site operators and purchasing companies with an upstream land footprint |
| **6.2** | • **Calculation guidelines for natural land cover** provides accounting and calculation guidelines for natural land cover for direct operations. (*Optional) companies can follow the direct operations approach for their upstream value chain if they have the requisite traceability and data.* |
| **6.3** | • **Calculation guidelines for soil organic carbon, soil erosion, and terrestrial acidification** provides the accounting and calculation guidelines for direct operations. (*Optional) companies can follow the direct operations approach for their upstream value chain if they have the requisite traceability and data.*<br>• The guidelines for calculating these land quality categories are split into four categories:<br>○ Activity assessment approach to calculate soil organic carbon and soil erosion impacts for direct operations which utilizes land environmental assessment factors<br>○ Alternative approach to calculate soil organic carbon which provides an overview of model-based, remote sensing-based and measurement-based approaches using the stock change account method derived from the (draft) GHG Protocol LSRG (2022)<br>○ Alternative approach to calculate soil erosion which outlines a method using the Revised Universal Soil Loss Equation (RUSLE)<br>○ Activity assessment approach for terrestrial acidification impacts for direct operations which utilizes characterization factors |

| | |
|---|---|
| **6.4** | • **Implementing response options** provides preliminary guidance to calculate a change in land quality values resulting from the implementation of select response options in direct operations, with a focus on land management practices |

## 6.0 Land area and quality impact categories (related to the SBTN Working Land Regeneration and Restoration target)

- **Land footprint:** For the purpose of these guidelines, land footprint refers to the land owned or controlled by the company or land required to produce the products it sources. Importantly, "land footprint" or "land occupation" refers to "working land" used for production in corporate supply chains — not necessarily all land owned or controlled by companies. Land that is not attributable to direct operations or upstream value chain activities is not included and thus reductions/improvements in impact categories are not applied to extensive land holdings held in reserve. These guidelines outline the approach to calculate land footprint in section 6.1.

- **Natural land cover:** In the context of these accounting guidelines, natural land cover refers to the proportion of (semi-)natural land present in a landscape. Increasing (semi-)natural land supports the delivery of Nature's Contributions to People (NCP). However, it is estimated that two-thirds of human-modified lands have insufficient (semi-)natural habitat. Work conducted by Mohamed *et al.,* (2024) found that biodiversity's capacity to pollinate crops, regulate pests and diseases, maintain clear water, limit soil erosion, and maintain recreation spaces for people significantly declines when the quantity of (semi-) natural habitat cover per $km^2$ falls below 20-25%. These guidelines provide an approach for companies to calculate natural land cover in their direct operations in section 6.2.

- **Soil organic carbon (SOC):** Soil organic carbon is carbon stored in soil organic matter and can act as a proxy indicator for a variety of ecosystem services. The Status of the World's Soil Resources Report (FAO and ITPS, 2015) notes that soil organic carbon loss is one of the ten major soil threats. Land use change and land management are two key drivers of soil organic carbon loss. The scope of these accounting guidelines is the provision of methods to calculate soil organic carbon within a companies' land footprint – land impacts associated with land use change are covered under the SBTN Land No Conversion target.

  The Global Guidance for Life Cycle Impact Assessment Indicators (UNEP, 2019) recommends using changes in SOC stock as a proxy indicator for soil quality impacts in life cycle assessment (LCA). Although the level of SOC stock does not represent all aspects of soil quality, it is positively correlated with several soil functions, including carbon transformations, nutrient cycling, soil structure maintenance, and the regulation of pests and diseases (Kibblewhite *et al.,* 2008 and De Laurentiis *et al.,* 2024). These guidelines outline an approach for companies to calculate soil organic carbon associated with their direct operations in section 6.3.

- **Soil erosion:** Erosion can be defined as the wearing away of the land surface by physical forces such as rainfall that abrade, detach, and remove soil or geological material from one point on the earth's surface to be deposited elsewhere (European Commission, 2020). One of the principal agents responsible for soil erosion is water and this erosion pathway can be accelerated by a range of human activities, such as tillage practice (Parsons, 2019 and Williams et al., 2009). The loss of soil through erosion has a range of adverse impacts including declines in organic matter and nutrient content, the breakdown of soil structure, and severe impacts on species sensitive to freshwater or marine sedimentation. Soil erosion can also lead to a reduction in the available soil water stored, which can result in an increased risk of flooding and landslides in adjacent areas. Nutrient and carbon cycling can be altered as eroded soil may lose 75-80% of its carbon content, with consequent release of carbon. To mitigate the effects of soil erosion, soil and water conservation strategies are required (European Commission, 2020). The guidelines outline an approach for companies to measure soil erosion, focusing on water as the mechanical force, associated with their direct operations in section 6.3.

- **Terrestrial acidification:** Is the process by which soil becomes more acidic. It is a change in soil chemical properties (e.g. decrease in soil pH) caused by the inputs and dissociation of compounds with acid-base chemistry, such as oxides of sulfur or nitrogen. Terrestrial acidification can reduce soil fertility, and significantly impact plant diversity, species richness and the occurrence of native plant species (Yadav *et al.,* 2020). The primary pollutants that lead to terrestrial acidification are nitrogen ($NH_3$ and $NO_X$) and sulfur ($SO_2$) emissions (European Environment Agency, 2008). The largest contributors to acidifying pollutants include fossil fuel combustion and agricultural activities. The focus of this target is on reducing terrestrial acidification through the reduction of its key contributing pollutants – nitrogen and sulfur emissions. These guidelines outline an approach for companies to measure terrestrial acidification associated with their direct operations in section 6.3.

## 6.1 Calculation guidelines for land footprint

The process to calculate a company's land footprint is described in Figure 9.

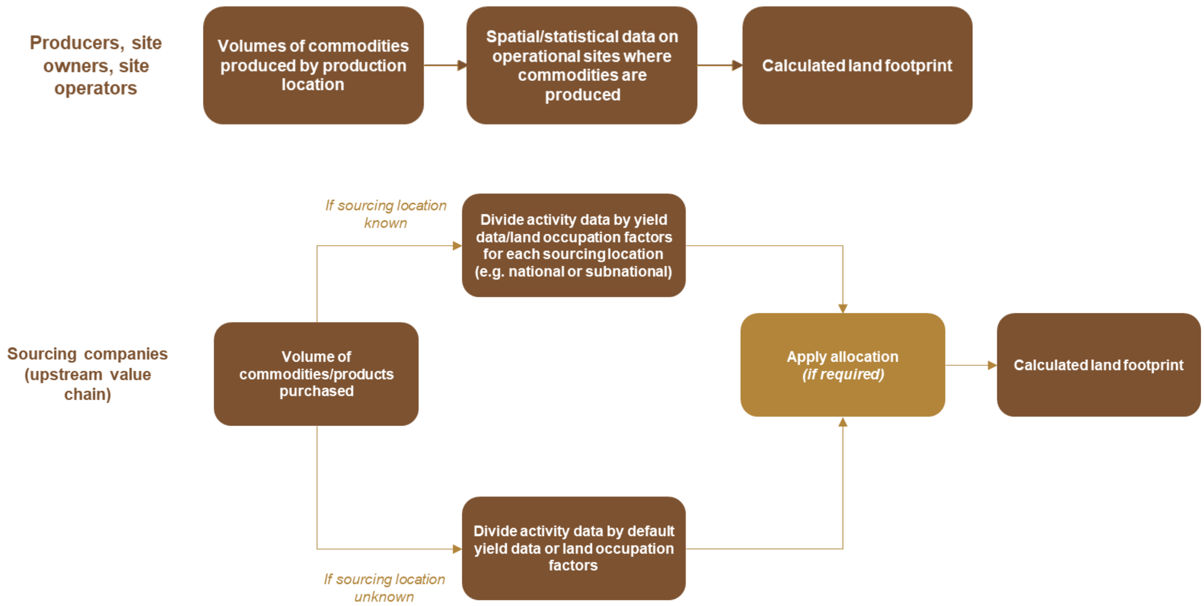



**Figure 9 Process for calculating land footprint disaggregated by producers/site owners/operations (direct operations) and sourcing companies (upstream value chain)**

### 6.1.1 Data requirements for calculating land footprint

To calculate land footprint, companies need to collect data as outlined in Table 12.

**Table 12 Data requirements for calculating land footprint**

| Stage of the value chain relevant to requirement | Data type | Unit | Spatial data requirements (Georeferenced polygons of production units or sourcing areas) |
|---|---|---|---|
| Producers or site owners/operators | Volumes of commodities produced by production location (primary or statistical data) | Metric tons | Recommended |
| Producers or site owners/operators | Data on operational sites where commodities are produced (spatial or statistical) | Hectares | Recommended |
| Sourcing from producers or first point of aggregation | Volumes of commodities purchased (primary or statistical data, differentiated to the extent possible by sourcing location) | Metric tons | Not required |
| Sourcing from producers or first point of aggregation | Yield of each product purchased (statistical data, matched to the extent possible with the sourcing locations linked to the purchasing volume data above (e.g., national or subnational yield data) | Metric tons per hectare per year | Not required |
| Sourcing downstream from the first point of aggregation | Volumes of commodities purchased (primary or statistical data, differentiated to the extent possible by sourcing location) | Metric tons | Not required |
| Sourcing downstream from first point of aggregation | Yield of each product purchased (statistical data, matched to the extent possible with the sourcing locations linked to the purchasing volume data above (e.g., national or subnational yield data) | Metric tons per hectare per year | Not required |

For companies with access to statistical data, land footprint can be calculated by using yields (e.g., crop yields) in t/ha/year to convert from metric tons of product to hectares, or also by using land occupation factors, essentially the reciprocal of yields, (e.g., square meter-year per kg (m2a/kg)) from LCA databases. Companies may refer to the SBTN Step 1 Toolbox and the (draft) GHG Protocol LSRG (2022) for lists of tools and databases that include yields and/or land occupation factors.

| Note on statistical data for land footprint |
| --- |
| If the company has already calculated GHG emissions associated with its land-based operations (scope 1) and/or value chain activities (scope 3), in line with reporting via the GHG Protocol and/or target setting via SBTi, the company is likely to already have its activity data well-organized for calculating the associated land footprint. The company may even be able to use the same environmental database that it used to calculate GHG emissions (e.g., Ecoinvent) to also calculate land footprint. |

### 6.1.2 Allocation

In instances where the land area sourced from is known, and it is known that multiple commodities are produced on that land area each year, for example co-products or crops grown in rotation, then an allocation approach may be needed. Please refer to Chapter 4 for guidance on selecting an appropriate allocation approach.

### 6.1.3 Calculating land footprint

To calculate land footprint, companies may collect spatial or statistical data.

#### Spatial approach

When using spatial data, companies should sum the hectares in all their active production areas to estimate total land footprint.

#### Statistical approach

- **Producers or site owners/operators (direct operations)**: statistical (non-spatial) data on quantities of commodities produced, and statistical or spatial data allowing for calculation of total surface area of working lands producing those commodities.
- **Sourcing companies (upstream value chain)**: statistical (non-spatial) data on quantities of commodities or derived products sourced, locations (e.g. countries and/or subnational jurisdictions) if known, and yield (output per hectare) of each product for each location.

Companies using statistical data to estimate total land footprint, the general approach is to divide activity data (e.g. production in metric tons) by yield factors (e.g. metric tons per hectare) to estimate the amount of land required annually, as demonstrated below ((draft) GHG Protocol LSRG, 2022). Companies would sum all estimates across all products to have their complete land footprint inventory.

| Land footprint for products (adapted from (draft) GHG Protocol LSRG, 2022) |
|---|
| Land footprint for products (ha) =<br><br>Quantity of product produced or purchased (t) / Yield of that product (t/ha)<br><br>Where:<br><br>ha = Hectares<br><br>t = Metric tons |

For food, feed, and energy feedstocks, global and national average yields can be accessed from online data repositories such as FAOSTAT or LCA databases or meta-analyses (e.g. Poore and Nemecek, 2018) ((draft) GHG Protocol LSRG, 2022). More specific yield information covering regional-, national-, or production unit-level can also be used.

When using statistical data, following the (draft) GHG Protocol LSRG (2022) guidance, companies *should* use the most spatially explicit data available for each commodity produced or purchased, and seek to improve traceability and data quality over time. For further details please refer to the (draft) GHG Protocol LSRG (2022) on accounting for land footprint

If a product's origin is not yet known, a default assumption (e.g., production assumed to be from the same world region as company headquarters) *may* be used to select the appropriate yield data if well justified to SBTN.

When estimating land footprint of purchased mixed products (i.e. products containing multiple commodities), companies *should* either try to back-calculate the amounts of raw products for the purpose of estimating land footprint (e.g. using product formulation or recipe data) or use reasonable assumptions to simplify the exercise without unduly sacrificing accuracy (e.g. categorizing each mixed product according to its primary ingredient or its top three ingredients). Because estimating land footprint using statistical data can never be perfect, emphasis *should* be given to estimating the land footprint related to products containing high-impact commodities (e.g. meat stews versus vegetable-based condiments).

**Note on waste and residual products**: If a company purchases residual products (i.e. by-products from other value chains) then the company should use an allocation method (e.g. by mass or by economic value) to estimate the land footprint of the purchased residual product. If a company sources (and does not purchase) a product that is truly a waste product (i.e. a product with no market value) it can be excluded from the land footprint.

**Note on non-timber forest products:** Where a company produces or sources non-timber forest products in land classified in FAOSTAT as forest then those volumes can be excluded from the land footprint calculation. This is in recognition of the role that low impact harvesting of non-timber forest products can have in bringing economic value to standing forests.

## 6.2 Calculation guidelines for natural land cover

This section provides guidelines for calculating natural land cover within direct operations.

**(Optional) companies can follow the direct operations approach for their upstream value chain if they have the requisite traceability and data.**

Calculating natural land cover follows a similar process to that outlined for calculating land use change using the SBTN Natural Lands Map outlined in Chapter 5. Note that the SBTN Natural Lands Map's definition of "natural land" includes "semi-natural land". As such, calculations of the percentage of natural land using the SBTN Natural Lands Map will inherently calculate the percentage of natural and semi-natural land.

To calculate natural land cover, companies:

- Map production units (and other operational areas) and locate them within the SBTN Natural Lands Map.
- Calculate natural land cover (%) at the level of production unit consulting the SBTN Natural Lands Map.

An overview of the process to calculate natural land cover is provided in Figure 10.


**Figure 10 Process to calculate natural land cover**

Companies with access to spatial data on natural land cover with higher resolution or higher accuracy than the SBTN Natural Lands Map and is more recent data than 2020, may use those data instead of the SBTN Natural Lands Map to calculate the baseline natural land cover.

Note, as outlined in Chapter 5, the SBTN Natural Lands Map may overestimate the area of natural land in some regions and as a result as better data become available, it is possible that the original calculation of natural land area (using the SBTN Natural Lands Map) could change. Companies should seek to improve the quality of the land cover data they collect over time.

### 6.2.1 Data requirements

To calculate natural land cover companies need to collect data on:

- Location and delineated area of production units that they own or manage (see definitions for ownership in SBTN Step 1 methods).
- Operational site areas (e.g., farms, mines, retail locations, infrastructure, and construction sites) that they own or manage.

**Table 13 Summary data requirements for natural land cover**

| Stage of the value chain | Data type | Unit | **Spatial data requirements** (Georeferenced point or polygon data of production units) |
|---|---|---|---|
| **Direct operations** | Location of all production units in direct operations | Hectares | Required |

### 6.2.2. Using the SBTN Natural Lands Map

Details on using the SBTN Natural Lands Map are provided in Chapter 5 and Annex 1c. The Map will enable companies to identify natural ecosystems within their production units. Note, the SBTN Natural Lands Map can only provide 2020 natural land cover data. As such, the choice of base year *must* be no earlier than 2020. (The base year does not need to align with the cutoff date(s) used as the reference for assessing conversion of natural ecosystems).

### 6.2.3 Accounting for natural land cover

Similar to the approach companies take to account for conversion of natural ecosystems, accounting for natural land cover at the production unit level requires known and mapped locations of the given production units. A step-by-step approach for companies to calculate natural land cover at the production-unit level is provided below and illustrated in Figure 11. Companies require either point or polygon spatial data of each production unit in their direct operations. If this is not immediately available, companies need to collect these data to calculate natural land cover.

A. Production units should be demarcated by georeferenced boundaries. Within each production unit, companies identify the center point. This center point marks the center of a grid comprised of one square kilometer (1 $km^2$) grid cells that companies will generate.

B. Once the grid is generated, companies identify each grid cell covered by at least 50% of the production unit polygon. This is the scope of the assessment of natural land cover for the production unit.

C. For each 1 $km^2$ grid cell covered by at least 50% of the production unit polygon, companies calculate the natural land cover by calculating the proportion of pixels from the SBTN Natural Lands Map (1 pixel = 30 x 30m) within the 1 $km^2$ grid cell that are classified as natural land.

D. Companies repeat this for each 1 $km^2$ grid cell covered by at least 50% of the production unit polygon to calculate the proportion of natural land cover for all cells in scope.

   For production units smaller than 1 $km^2$ and/or for production units that cover only a fraction of a 1 $km^2$ grid cell, companies calculate the proportion of SBTN Natural Lands Map pixels classified as natural land that the production unit covers.

To determine the representative percentage (%) of natural land cover per $km^2$ for each production unit, companies calculate the average natural land cover values across the 1 $km^2$ grid cells covered by the production-unit polygon.

For companies using these guidelines to set an SBTN Land Natural Land Cover target, companies are required to set a target of 25% natural land cover per $km^2$ or 25 hectares for production units within an area of 1$km^2$.

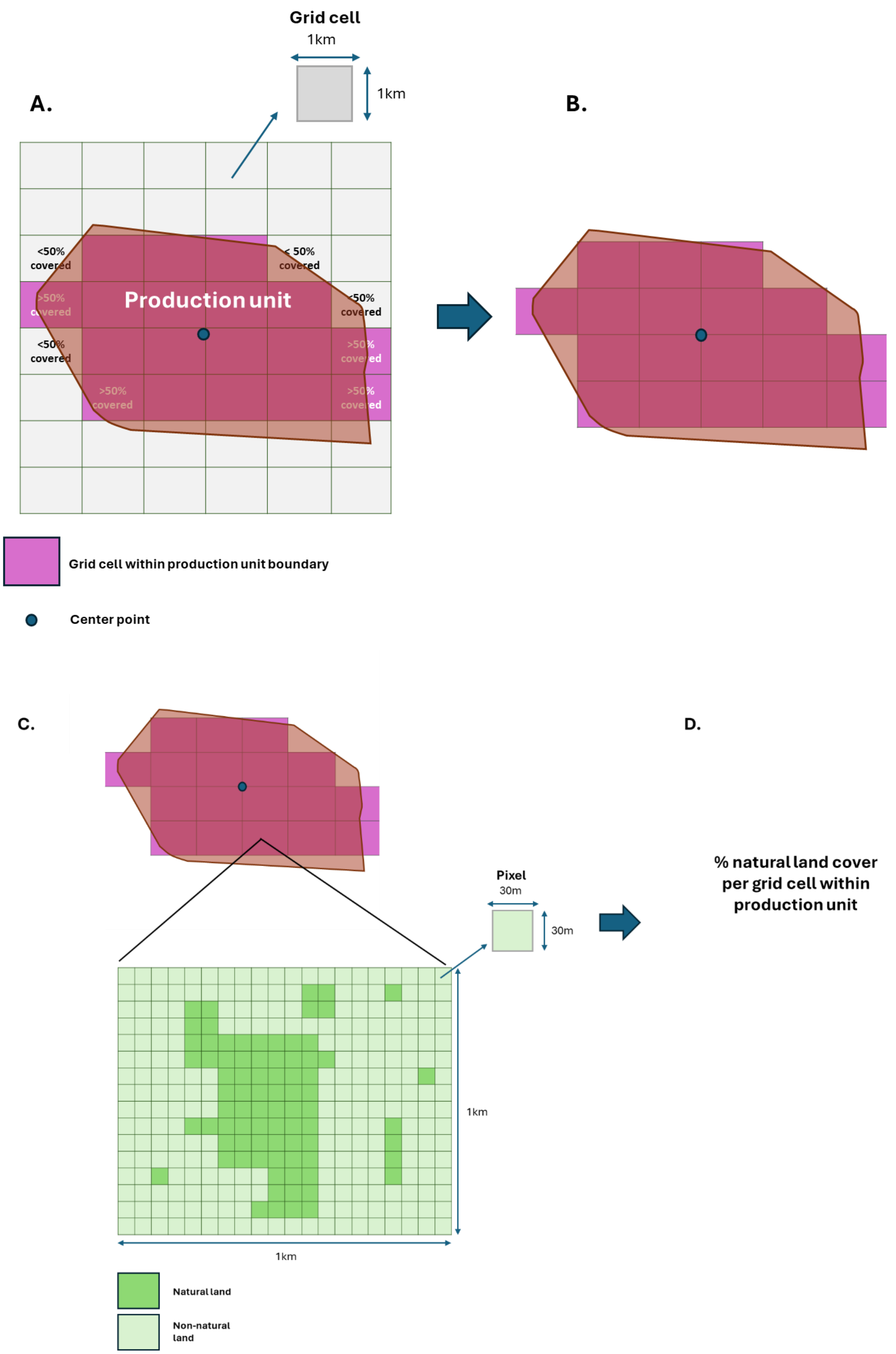



**Figure 11 Illustrative process for calculating natural land within a production unit**

## 6.3 Calculation guidelines for soil organic carbon, soil erosion and terrestrial acidification

This section provides guidelines for companies to calculate soil organic carbon (SOC), soil erosion and terrestrial acidification for their direct operations.

**(Optional) companies can follow the direct operations approach for their upstream value chain if they have the requisite traceability and data.**

These guidelines provide the following methods:

1. **Activity assessment approach for SOC and soil erosion:** Method to calculate SOC and soil erosion using Maximum Attainable SOC stock (MaxSOC) and soil erosion rates for geographically-specific land use types.

2. **Alternative approach to calculate SOC:** Model-based, remote sensing-based and measurement-based approaches using the stock change accounting method derived from the (draft) GHG Protocol LSRG (2022).

3. **Alternative approach to calculate soil erosion:** Revised Universal Soil Loss Equation (RUSLE).

4. **Activity assessment approach for terrestrial acidification:** Method to calculate terrestrial acidification based on emissions data (in kg) using characterization factors (kg $SO_2$-eq/kg) to transform them into terrestrial acidification potential.

**Land Environmental Assessment Factors (LEAFs ) and Characterization Factors (CFs)**

A characterization factor is derived from a characterization model which is applied to convert an assigned life cycle inventory analysis result to the common unit of the impact category indicator (ISO 14040).

Characterization factors are numerical factors that help translate companies' activities, including their operations, products, services and purchases, into different environmental impacts, by using the elementary flows (e.g., land use, water consumption, emissions into air, water and land) collected for the company inventory. Characterization factors represent the unit impact for each impact category and differ by elementary flow. They are calculated through characterization models, which can differ in scope, complexity, impact pathways, data used, and unit of measurement.

One of the most common set of characterization factors is used to calculate carbon footprints to estimate the contribution of a product or company towards climate change. In this case, the elementary flows are GHG emissions, which are emitted or captured from the atmosphere, and are measured in kg of $CO_2$ equivalent (kg $CO_2$e). Each GHG has a different characterization factor depending on whether it contributes more or less to climate change compared to carbon dioxide. For example, 1 kg of carbon dioxide emitted to the atmosphere has a characterization factor equal to 1 kg of $CO_2$-eq., as it is used as reference, but 1 kg of methane from fossil fuel combustion has a value of 29.8 kg of $CO_2$-eq. according to IPCC's AR6 report.

Land use impacts characterization factors are calculated differently. In this case, they are calculated as the difference in an indicator between a reference state, usually what is called a quasi-natural state, and another land use. For example, for SOC, the characterization factor for grassland land occupation in a specific ecoregion would be the difference between SOC stock in that ecoregion's quasi-natural state (reference state), and the SOC stock of grassland. The same can be applied to soil erosion.

In the guidelines, companies use characterization factors to estimate their contribution towards terrestrial acidification. For SOC and soil erosion, companies will use the land quality indicator for their current land use instead of traditional characterization factors, as they can be more easily compared with ecoregion's threshold needed for target-setting. Together, these factors are called Land Environmental Assessment Factors (LEAFs). Methods were selected with the help of The Norwegian University of Science and Technology (NTNU) to best align with SBTN objectives, including availability at the ecoregion level, scientific community acceptance, and ease of use.

Note, these factors have been recalculated from their original publications at different levels of granularity (country, sub-country, ecoregion and via GIS mapping) to support companies with varying levels of traceability and data accessibility. Further, LEAFs can also help companies to estimate how much each response option implemented will help them improve their impacts. Due to the nascent nature of these methods, it is possible that a specific production practice does not have a characterization factor already calculated. Section 6.4 provides preliminary guidance on how to use characterization factors to calculate the impact of select response options – note these methods are limited to companies' direct operations.

Finally, it should be noted that LEAFs, and characterization factors, are not the same as emission factors, which are commonly used to calculate corporate footprints under the GHG Protocol and SBTi. These are derived by adding the impacts of all elementary flows of a product's supply chain towards a specific point, using their corresponding characterization factors for a specific impact category.

### 6.3.1 Activity assessment approach for SOC and soil erosion

Calculating SOC and soil erosion consists of a three-step process:

1. Collect inventory data
2. Select baseline MaxSOC stock and soil erosion rate
3. Calculate the baseline for each production unit based on their land use types

This approach utilizes a set of MaxSOC derived from Morais *et al.,* (2019), which calculated, using the Rothamsted Carbon (RothC) model, the MaxSOC stock of a given land use in a specific site if it is kept the same over extended periods of time. These factors have been adjusted to 2035 to be in line with the SBTN Working Land Regeneration and Restoration target, and 2050 for companies choosing to set long-term targets.

Soil erosion rates have been calculated globally at 25 km resolution based on De Laurentiis *et al.,*(2019) proposed GIS approach, which follows RUSLE. The RUSLE equation is a simple multiplication of 6 factors: Rainfall erosivity factor (R), soil erodibility factor (K), slope length and slope steepness factor (LS), Ground cover and tillage factor (C), and erosion protection or practice factor (P). Factors R, K, and LS have been obtained from GloSEM v1.1 publicly available rasters (Borelli *et al.*, 2017). C factors layers were created using Morais *et al.,* (2019) MaxSOC as a base for land use layer, and assigning C factors based Supplementary Materials Table 1 and 2 from Borelli *et al.,* (2017). P factor was assigned as 1 per De Laurentiis *et al.,* (2019) methods, due to their local nature.

The MaxSOC stock factors and soil erosion rates have been recalculated at different levels of granularity (country, sub-country, ecoregion and via GIS mapping) to support companies with varying levels of traceability and data accessibility. A summary is provided below.

**Table 14 Overview of SOC stock factors and soil erosion rates provided under the activity assessment approach**

| | Soil Organic Carbon | Soil Erosion |
|---|---|---|
| **Explanation** | Maximum attainable SOC (MaxSOC) per land use type (stock) | Soil erosion due to different land use types (rate) |
| **LEAF unit** | t C/ha | t soil/ha |
| **Data Needed** | Land use and duration by location and intensity (ha*yr) | Land use and duration by location and intensity (ha*yr) |
| **Method** | Morais, T.G., Teixeira, R.F.M., and Domingos, T. (2019) Detailed global modelling of soil organic carbon in cropland, grassland and forest soils. PLoS ONE 14(9): e0222604. | De Laurentiis, V., Secchi, M., Bos, U., Horn, R., Laurent, A., and Sala, S. (2019). Soil quality index: Exploring options for a comprehensive assessment of land use impacts in LCA. Journal of Cleaner Production, 215, 63-74. |
| **Underlying model** | Rothamsted Carbon (RothC) model | Revised Universal Soil Loss Equation (RUSLE) as the basis for LANd use indicator value Calculation (LANCA) model |
| **Granularity** | Map* (10 km resolution), Country*, Sub-Country**, Ecoregion** | Map[+] (25 km resolution), Country*, Sub-Country[+], Ecoregion[+] |

* Available from the original publication
** Recalculated from the original publication
+ Original calculation aligned with soil erosion method
++ Recalculated from original calculated and normalization error fixed using ImpactWorld+ data.

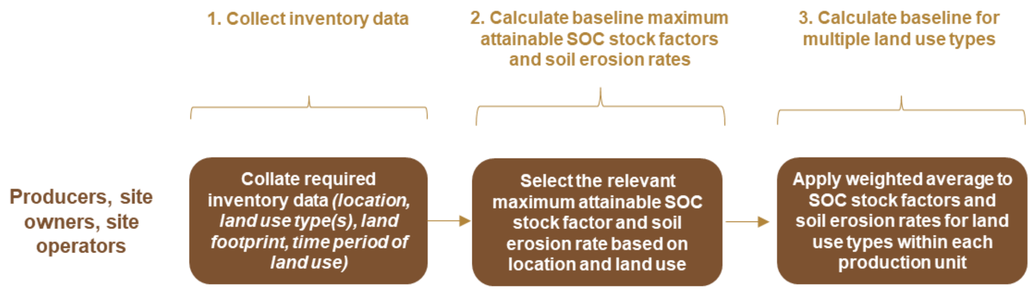



**Figure 12 Process for calculating SOC and soil erosion using the SBTN assessment method**

## Step 1. Collect inventory data

The first step in the process consists of companies compiling an inventory of land use data. Companies will need to collate inventory data in a prescribed format as outlined in Table 15.

**Table 15 Inventory data for the calculation of SOC and soil erosion**

| Step | Inventory data collection |
|---|---|
| **1. Identify the location(s) of direct operations** | • The set of MaxSOC stocks and soil erosion rates provided are available at the country, sub-country, ecoregion and via GIS mapping. As such, companies will need to identify the locations of each production unit. |
| **2. Identify land use types in direct operations** | • Companies identify specific land use types within each production unit.<br>• The land use types included in this method are provided in Table 16 and Table 17.<br>• Companies match their land use types to those provided in either Table 16 or Table 17.<br>• Table 17 is the preferred approach as it provides more detailed land use types that companies should use if they have appropriate traceability. |
| **3. Calculate land footprint per production unit** | • For companies with multiple land use types within a production unit, they will need to calculate the land footprint for each land use type within that production unit and apply a weighted average to the related SOC stock(s) and/or soil erosion rate(s) for each land use type at the production-unit level.<br>• To calculate this, companies can follow the guidelines for calculating land footprint in section 6.1. |
| **4. Calculate time period of land use** | • When calculating their land footprint, companies calculate the time period for each land use type in hectares per year.<br>• The MaxSOC stocks and soil erosion rates provided are based on a unit of mass per area per year. As such, the input data from companies need to reflect the period under one land use type within the year of assessment (e.g. 6 months = 0.5 year) |

**Table 16 Land use/cover class descriptions (adapted Koellner *et al.*, 2013)**

| Land use/cover class | Description |
|---|---|
| **Unspecified** | Land use and cover not known |
| **Unspecified, used** | Human land use and resulting land cover not known |
| **Unspecified, natural (*)** | Natural land cover not known |
| **Forest[a]** | Areas with tree cover >15% |
| **Forest, natural (*)** | Forest not used by humans |
| **Forest, primary** | Forests minimally disturbed by human impact, where flora and fauna species abundance is near pristine |
| **Forest, secondary** | Areas originally covered with forest or woodlands, where vegetation has been removed, forest is re-growing and is no longer in use |
| **Forest, used** | Forests used by humans |
| **Forest, extensive** | Forests with extractive use and associated disturbance like hunting, and selective logging, where timber extraction is followed by re-growth including at least three naturally occurring tree species |
| **Forest, intensive** | Forests with extractive use, with either even-aged stands and clear-cut patches, or less than three naturally occurring species at planting/seeding |
| **Wetlands** | Areas regularly flooded, eventually with tree cover, closed to open (>15%) |
| **Wetlands, coastal [b](*)** | Areas tidally, seasonally or permanently waterlogged with brackish or saline water. Includes costal marshland, mangroves and salt marshes. Excludes coastal land with infrastructure or agriculture |
| **Wetlands, inland [c](*)** | Areas partially, seasonally, or permanently waterlogged. The water may be stagnant or circulating. Includes inland marshland, swamp forests and peat bogs |

| | |
|---|---|
| **Shrub land [d](*)** | Areas with shrub-dominated sclerophyllous vegetation |
| **Grassland [e]** | Herbaceous cover, closed to open (>15%) with scattered shrubs or trees |
| **Grassland** | Naturally grassland dominated vegetation |
| **Grassland, natural (*)** | Grassland-dominated vegetation, fauna and flora near pristine (e.g., steppe, tundra, savannah) |
| **Grassland, for livestock grazing** | Grasslands where wildlife is replaced by grazing livestock |
| **Pasture/meadow** | Areas that have been converted to grasslands for livestock grazing or fodder production |
| **Pasture/meadow, extensive** | Pasture with low number of livestock or meadows mechanically harvested 2 or 3 times per year, reduced input of fertilizer |
| **Pasture/meadow, intensive** | Pasture with high number of livestock or meadows mechanically harvested 3 times or more per year, fertilizer applied |
| **Agriculture [f]** | Areas used for crop production |
| **Arable** | Cultivated areas regularly ploughed and generally under a rotation system. Cereals, legumes, fodder crops, and root crops. Includes flower and tree (nurseries) cultivation and vegetables as well as aromatic, medicinal and culinary plants. Excludes permanent pastures |
| **Arable, fallow** | Cropland temporarily not used (<2 years) |
| **Arable, non-irrigated** | Annual crop production based on natural precipitation (rainfed agriculture) |
| **Arable, non-irrigated, extensive** | + Use of chemical–synthetic and organic fertilizer as well as pesticides is reduced |
| **Arable, non-irrigated, intensive** | + Chemical–synthetic and organic fertilizer as well as pesticides are applied |

| | |
|---|---|
| **Arable, irrigated** | Annual crops irrigated permanently or periodically, using a permanent infrastructure (irrigation channels, drainage network). Most of these crops like rice could not be cultivated without an artificial water supply. Does not include sporadically irrigated land |
| **Arable, irrigated, extensive** | + Use of chemical–synthetic and organic fertilizer as well as pesticides is reduced |
| **Arable, irrigated, intensive** | + Chemical–synthetic and organic fertilizer as well as pesticides are applied |
| **Arable, flooded crops** | Areas developed for rice cultivation. Flat surfaces with irrigation channels. Surfaces regularly flooded |
| **Arable, greenhouse** | Crop production under plastic or glass |
| **Field margins/hedgerows** | Areas between fields with natural vegetation |
| **Permanent crops** | Perennial crops not under a rotation system which provide repeated harvests and occupy the land for a long period before it is ploughed and replanted: mainly plantations of woody crops |
| **Permanent crops, non-irrigated** | Perennial crops production based on natural precipitation (rainfed agriculture) |
| **Permanent crops, non-irrigated, extensive** | + Use of chemical–synthetic and organic fertilizer as well as pesticides is reduced |
| **Permanent crops, non-irrigated, intensive** | + Chemical–synthetic and organic fertilizer as well as pesticides are applied |
| **Permanent crops, irrigated** | Perennial crops with artificial input of water |
| **Permanent crops, irrigated, extensive** | + Use of chemical–synthetic and organic fertilizer as well as pesticides is reduced |

| | |
|---|---|
| **Permanent crops, irrigated, intensive** | + Chemical-synthetic and organic fertilizer as well as pesticides are applied |
| **Agriculture, mosaic** [g] | Heterogeneous, agricultural production intercropped with (native) trees. Trees or shrubs are kept for shade or as wind shelter; or use of timber or non-timber products (e.g., agroforestry) |
| **Artificial areas** [h] | Artificial surfaces and associated area(s) |
| **Urban** | Areas with infrastructure for living and businesses |
| **Urban/industrial fallow** | Areas with remains of industrial buildings; deposits of rubble, gravel, sand and industrial waste. Can be vegetated |
| **Urban, continuously built** | Buildings cover most of the land. Roads and artificially surfaced area cover almost all the ground. Non-linear areas of vegetation and bare soil are exceptional. At least 80% of the total area is sealed |
| **Urban, discontinuously built** | Most of the land is covered by structures. Buildings, roads, and artificially surfaced areas associated with areas with vegetation and bare soil, which occupy discontinuous but significant surfaces. Less than 80% of the total area is sealed |
| **Urban, green areas** | Areas with vegetation within urban fabric. Includes parks with vegetation |
| **Industrial area** | Artificially surfaced areas (with concrete, asphalt, or stabilized, e.g., beaten earth) devoid of vegetation occupy most of the area in question, which also contains buildings and/or areas with vegetation |
| **Mineral extraction site** | Areas with open-pit extraction of industrial minerals (sandpits, quarries) or other minerals (opencast mines). Includes flooded gravel pits, except for riverbed extraction |
| **Dump site** | Landfill or mine dump sites, industrial or public |
| **Construction site** | Areas under construction development, soil or bedrock excavations, earthworks |

| | |
|---|---|
| **Traffic area** | Areas used for traffic infrastructure |
| **Traffic area, road network** | Motorways, including associated installations (gas stations) |
| **Traffic area, rail network** | Railways, including associated installations (stations, platforms) |
| **Traffic area, rail/road embankment** | Vegetated area along motorways and railways |
| **Bare area [i](*)** | Areas permanently without vegetation (e.g., deserts, high alpine areas) |
| **Snow and ice [j](*)** | Areas permanently covered with snow or ice considered undisturbed |

The (*) marks land cover types, which serve as a natural reference. Classification according to GLC 2000 (Bartholomé and Belward 2005)

a. Tree cover, broad-leaved evergreen, closed to open (>15%); Tree Cover, broad-leaved deciduous, closed (>40%); Tree cover, broadleaved deciduous, open (15–40%); Tree cover, needle-leaved evergreen, closed to open (>15%); Tree cover, needle-leaved deciduous, closed to open (>15%); Tree cover, mixed leaf type, closed to open (>15%); Mosaic of tree cover and other natural vegetation; Tree cover, burnt (mainly boreal forests)

b. Tree cover, closed to open (>15%), regularly flooded, saline water: mangrove forests

c. Tree cover, closed to open (>15%), regularly flooded, fresh or brackish water: swamp forests; Regularly flooded (>2 months) shrub and/or herbaceous cover

d. Shrub cover closed to open (>15%), evergreen (broad-leaved or needle-leaved); Shrub cover closed to open (>15%), deciduous (broad leaved); Sparse herbaceous or sparse shrub cover

e. Herbaceous cover, closed to open (>15%)

f. Cropland (upland crops or inundated/ flooded crops as, e.g., rice)

g. Mosaic of cropland/tree cover/other natural vegetation; Mosaic of cropland/shrub or herbaceous cover

h. Artificial surfaces and associated area(s)

i. Bare areas

j. Snow and ice

+ Perennial crops production based on natural precipitation (rainfed agriculture) with use of chemical–synthetic and organic fertilizer as well as pesticides is reduced

**Table 17 Crop-specific land use types**

| Land use/cover class | Description |
|---|---|
| Grasslands | Grasslands |
| Urban | Urban |
| Forests – Broadleaf Deciduous | Boreal dry |
| Forests – Broadleaf Deciduous | Boreal moist |
| Forests – Broadleaf Deciduous | Cold temperate dry |
| Forests – Broadleaf Deciduous | Cold temperate moist |
| Forests – Broadleaf Deciduous | Subtropical |
| Forests – Broadleaf Deciduous | Tropical |
| Forests – Broadleaf Deciduous | Warm temperate dry |
| Forests – Broadleaf Deciduous | Warm temperate moist |
| Forests – Needleleaf Evergreen | Boreal dry |
| Forests – Needleleaf Evergreen | Boreal moist |
| Forests – Needleleaf Evergreen | Cold temperate dry |
| Forests – Needleleaf Evergreen | Cold temperate moist |
| Forests – Needleleaf Evergreen | Subtropical |

| | |
|---|---|
| Forests – Needleleaf Evergreen | Tropical |
| Forests – Needleleaf Evergreen | Warm temperate dry |
| Forests – Needleleaf Evergreen | Warm temperate moist |
| Irrigated | Apples, Irrigated |
| Irrigated | Bananas, Irrigated |
| Irrigated | Barlet, Irrigated, Residues left on field |
| Irrigated | Barley, Irrigated, Residues removed from field |
| Irrigated | Cabbages, Irrigated |
| Irrigated | Carrots, Irrigated |
| Irrigated | Cocoa, Irrigated |
| Irrigated | Coconuts, Irrigated |
| Irrigated | Coffee, Irrigated |
| Irrigated | Cotton, Irrigated |
| Irrigated | Grapes, Irrigated |
| Irrigated | Groundnuts, Irrigated |
| Irrigated | Maize, Irrigated, Residues left on field |

| | |
|---|---|
| Irrigated | Maize, Irrigated, Residues removed from field |
| Irrigated | Palm oil, Irrigated |
| Irrigated | Olives, Irrigated |
| Irrigated | Onions, Irrigated |
| Irrigated | Oranges, Irrigated |
| Irrigated | Potatoes, Irrigated |
| Irrigated | Rapeseed (canola), Irrigated, Residues left on field |
| Irrigated | Rapeseed (canola), Irrigated, Residues removed from field |
| Irrigated | Rice, Irrigated |
| Irrigated | Sorghum, Irrigated, Residues left on field |
| Irrigated | Sorghum, Irrigated, Residues removed from field |
| Irrigated | Soybean, Irrigated |
| Irrigated | Sugarbeet, Irrigated |
| Irrigated | Sugarcane, Irrigated |
| Irrigated | Sunflower, Irrigated |
| Irrigated | Sweet potatoes, Irrigated |

| | |
|---|---|
| Irrigated | Tobacco, Irrigated |
| Irrigated | Tomatoes, Irrigated |
| Irrigated | Wheat, Irrigated, Residues left on field |
| Irrigated | Wheat, Irrigated, Residues removed from field |
| Rainfed | Apples, Rainfed |
| Rainfed | Bananas, Rainfed |
| Rainfed | Barley, Rainfed, Residues left on field |
| Rainfed | Barley, Rainfed, Residues removed from field |
| Rainfed | Cocoa, Rainfed |
| Rainfed | Coconuts, Rainfed |
| Rainfed | Coffee, Rainfed |
| Rainfed | Cotton, Rainfed |
| Rainfed | Grapes, Rainfed |
| Rainfed | Groundnuts, Rainfed |
| Rainfed | Maize, Rainfed, Residues left on field |
| Rainfed | Maize, Rainfed, Residues removed from field |

| | |
|---|---|
| Rainfed | Palm oil, Rainfed |
| Rainfed | Olives, Rainfed |
| Rainfed | Oranges, Rainfed |
| Rainfed | Potatoes, Rainfed |
| Rainfed | Rapeseed (canola), Rainfed, Residues left on field |
| Rainfed | Rapeseed (canola), Rainfed, Residues removed from field |
| Rainfed | Rice, Rainfed |
| Rainfed | Sorghum, Rainfed, Residues left on field |
| Rainfed | Sorghum, Rainfed, Residues removed from field |
| Rainfed | Soybean, Rainfed |
| Rainfed | Sugarbeet, Rainfed |
| Rainfed | Sugarcane, Rainfed |
| Rainfed | Sunflower, Rainfed |
| Rainfed | Sweet potatoes, Rainfed |
| Rainfed | Tobacco, Rainfed |
| Rainfed | Tomatoes, Rainfed |

| | |
|---|---|
| Rainfed | Wheat, Rainfed, Residues left on field |
| Rainfed | Wheat, Rainfed, Residues removed from field |

The SBTN Land Hub acknowledges the current limitations on the lack of more specific land use categories to characterize grasslands and forests land quality categories, and is currently working on expanding them to be included in the final release of the guidelines.

### Step 2 Select baseline maximum attainable SOC stock factors and soil erosion rates

Note this step undertaken separately for SOC and soil erosion.

Once a company has collected its inventory data into the required format (i.e. by location, land use and intensity type) for each production unit, it will need to select the relevant MaxSOC stock and soil erosion rate *[placeholder for link to MaxSOC stocks and soil erosion rates*]. This will provide the baseline SOC and soil erosion for each production unit (see the example provided in Table 18 below).

It is recommended that companies use the GIS maps provided to select the relevant MaxSOC stock and soil erosion rate as the maps enable a more granular approach. Companies will need to collate spatial data on production units in direct operations and overlay these with the GIS maps provided [*placeholder for link to GIS maps*] to select the appropriate MaxSOC stock(s) and soil erosion rate(s).

For companies that do not have GIS capabilities, they may use ecoregions. Sub-country and country-level MaxSOC stock(s) and soil erosion rate(s) are also available for companies without access to GIS maps or ecoregion data, and should be selected in that given order of preference.

### Step 3 Calculate the baseline for multiple land use types

For companies with more than one land use type on a production unit, they will need to apply a weighted average to the relevant MaxSOC stocks and soil erosion rates to calculate the baseline for the production unit. Companies will need the land footprint per land use type within each production unit and apply a weighted average across the selected MaxSOCs and soil erosion rates to calculate one factor and rate for each production unit.

This approach may also be required for companies using the GIS maps.

**Table 18 Example baseline MaxSOC stock and soil erosion rate**

| Dimension | Ecoregion Example | Ecoregion Example |
|---|---|---|
| **Commodity** | **Milk, fresh** | **Sugarcane** |
| **Max Attainable SOC (t C/ha)** | 69 | 38.5 |
| **Soil Erosion Rate (t soil/ha)** | 0.75 | 34 |

## 6.3.2 Alternative approaches to calculating soil organic carbon and soil erosion

Companies may adopt an alternative approach to calculate SOC and soil erosion where such methods lead to more accurate estimations of each impact category than those provided by the above method.

A company may seek to use alternative methods where more granular data is available on SOC and soil erosion, for example, collected via direct measurement, satellite data and model-based approaches. Using more accurate data will provide companies with a better estimation of their impacts to enable improved target-setting and how to reach them.

When using alternative approaches to calculate SOC and soil erosion, companies should also ensure that methods used are compatible with the SOC stock factors and soil erosion rates outlined in section 6.3.1.

## Alternative methods to calculate soil organic carbon

This section summarizes the (draft) GHG Protocol LSRG (2022) methods to calculate soil carbon stock changes using the stock-change accounting method. Stock-change accounting estimates net biogenic $CO_2$ emissions or removals and the associated net land carbon stock changes. Whilst these guidelines do not focus on emissions or removals, this accounting method can be used to calculate changes in soil carbon.

Net land carbon stock changes can be calculated using either the stock-difference method or gain-loss method.

### Stock-Difference Method

The stock-difference method quantifies the net land carbon stock change based on the change in total carbon stocks across land-based carbon pools (aboveground biomass, belowground biomass, dead organic matter and soil carbon) over time.

**Stock-difference method for net land carbon stock changes ((draft) GHG Protocol LSRG, 2022)**

$$\Delta C_L = \frac{C_{L,f} - C_{L,i}}{t_f - t_i}$$

$\Delta C_L$ = Net land carbon stock change in land strata, $L$ (metric tons C $yr^{-1}$)

C = Land carbon stock in land strata, $L$ in the final year $C_{L,f}$ and initial year $C_{L,i}$(metric tons C)

t = time at the final $t_f$ and initial $t_i$ estimate (year)

### The Gain-Loss Method

The gain-loss method quantifies the net land carbon stock change based on the difference between carbon gains (gross $CO_2$ removals and other non-atmospheric carbon inputs to land-based carbon pools) and carbon losses (gross $CO_2$ emissions and other carbon transfers from land-based carbon pools) in a given period.

**Gain-loss method for net land carbon stock changes ((draft) GHG Protocol LSRG, 2022)**

$$\boldsymbol{\Delta C_L = G - L = (R_L + I_L) - (E_L + T_L)}$$

$\Delta C_L$ = Net land carbon stock change in land strata, $L$ (metric tons C $yr^{-1}$)

$G_L$ = Annual land carbon stock gains in land strata, $L$ (metric tons C $yr^{-1}$)

$L_L$ = Annual land carbon stock losses in land strata, $L$ (metric tons C $yr^{-1}$)

$R_L$ = Annual land carbon stock gains from gross biogenic land $CO_2$ removals in land strata, $L$ (metric tons C $yr^{-1}$)

$I_L$ = Annual land carbon stock gains from non-atmospheric C inputs to land strata, $L$ (metric tons C $yr^{-1}$)

$E_L$ = Annual land carbon stock losses from gross biogenic land $CO_2$ emissions in land strata, $L$ (metric tons C $yr^{-1}$)

$T_L$ = Annual land carbon stock losses due to harvested C and other C transfers from land strata, $L$ (metric tons C $yr^{-1}$)

A summary of land carbon stock change accounting methods is provided below for model-based approaches, remote sensing-based approaches and measurement-based approaches. For further information on these methods please see the (draft) GHG Protocol LSRG (2022).

### Model-based approaches

Process-based biophysical models of agro-ecosystems can be used to simulate changes in soil carbon stocks resulting from land management changes. These models account for specific field and location conditions such as soil properties, topography, weather, and comprehensive management decisions including crop rotation, tillage intensity, irrigation, nutrient management, residue management and other in-field practices. Process-based models require substantial background data on environmental conditions and accurate parameterization for a given region and set of circumstances. These models additionally require periodic calibration against measured values and updating of supporting environmental data. For further details on model-based approaches, see the (draft) GHG Protocol LSRG (2022).

The Rothamsted Carbon (RothC) Model is a well-accepted soil process model that simulates SOC turnover that follows the Stock-Difference method and is publicly available. It is the used to estimate the  MaxSOC stock used in this guidance (Morais *et al.*, 2019).. Companies are recommended to use this method to ensure consistency and comparability to default MaxSOC stocks.

### Remote sensing-based approaches

Soil carbon cannot be detected directly through satellite remote sensing; however, these approaches can be used to detect changes in land cover and management. Land cover and management data sourced from remote sensing products can be used to estimate changes in soil carbon stocks using emission factors, statistical models, or process-based models. Land cover changes remote sensing methods are relatively advanced and accessible. However, land management change remote sensing is primarily focused on detecting changes in crop rotation and changes in tillage intensity. As such, it may not apply to all relevant land management practices ((draft) GHG Protocol, 2022).

### Measurement-based approaches

A sampling protocol can be used to measure soil carbon stock change on a select portion of the land area contributing to the soil carbon stock changes. Companies should follow an established sampling protocol that accounts for variation of environmental factors and stratifies total land area to ensure that measurements are taken in representative locations of the spatial boundaries. Soil properties and management practice changes in sampled areas must be representative of the total land area contributing to the soil carbon stock changes. For further details on measurement-based approaches, see the (draft) GHG Protocol LSRG (2022).

## Alternative methods to calculate soil erosion

The two main mechanical forces that cause erosion are water and wind. Current methods to calculate soil erosion impacts focus on water erosion. The widely accepted model to calculate soil loss due to water flow is the Revised Universal Soil Loss Equation (RUSLE) (Renard *et al.,* 1997) developed by the United States Department of Agriculture.

| Revised Universal Soil Loss Equation (RUSLE) |
| --- |
| **A = R * K * LS * C * P**<br><br>Where:<br><br>A = estimated average soil loss in t/ha/yr<br><br>R = rainfall-runoff erosivity (mm ha-1 yr-1)<br><br>K = soil erodibility (mg ha-1 yr-1)<br><br>LS = slope length and steepness<br><br>C = land cover and management (e.g. cropland, grassland and forest)<br><br>P = support practices (e.g. reduced tillage, contouring and vegetation strips) |

The accuracy and availability of variables differ across the world. While there is abundant data to obtain R and LS factors using global meteorological data and elevation maps, for C and P regional land use practices and management strategies are needed. Examples of LS factors are provided in Panagos *et al.,* (2015); K factors in Panagos *et al.,* (2014) and Gupta *et al.,* (2024); R factors in Panagos *et al.,* (2017); and C and P factors in Ebabu *et al.,* (2022).

RUSLE can also be used with geospatial techniques such as remote sensing and geographic information systems (GIS) to improve the accuracy of the erosion estimation e.g. Almouctar *et al.,* (2021).

Companies with the requisite data and resources may calculate soil erosion following the approaches outlined in Bos *et al.,*(2016) and De Laurentiis *et al.,* (2019) or a similar credible method.

### 6.2.3 Activity assessment approach for terrestrial acidification

Calculating terrestrial acidification associated with direct operations consists of a three-step process:

1. Collect inventory data.
2. Match inventory data with characterization factors.
3. Calculate impact.

**Table 19 Overview of terrestrial acidification characterization factors provided under the activity assessment approach**

| | Terrestrial Acidification |
|---|---|
| **Explanation** | Change in acidity in the soil due to a change in acid deposition coming from nitrogen and sulfur emissions |
| **CF unit** | kg $SO_2$-eq/kg |
| **Data Needed** | Emissions of $NH_3$, $NO_x$, and $SO_2$ (kg) per location<br><br>Land footprint per production unit (ha) |
| **Method** | Roy, P. O., Azevedo, L. B., Margni, M., van Zelm, R., Deschênes, L., & Huijbregts, M. A. (2014). Characterization factors for terrestrial acidification at the global scale: A systematic analysis of spatial variability and uncertainty. Science of the Total Environment, 500, 270-276. |
| **Underlying model** | Combination of GEOS-Chem, PROFILE, model and species richness – pH response curves. |
| **Granularity** | Map++ (2° × 2.5° grid resolution), Country++, Sub-Country++, Ecoregion++ |

* Available from the original publication
** Recalculated from the original publication
\+ Original calculation aligned with soil erosion method
\++ Recalculated from original calculated and normalization error fixed using ImpactWorld+ data.

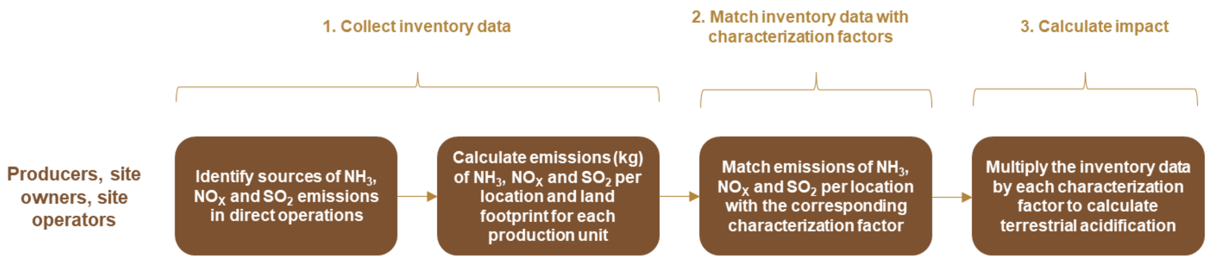



**Figure 13 Process for calculating terrestrial acidification**

## Step 1. Collect inventory data

To calculate terrestrial acidification, companies need to calculate their annual emissions of $NH_3$, $NO_X$ and $SO_2$ in kg/ha for each production unit location in their direct operations. Companies are recommended to calculate their acidifying emissions for the whole production unit and then divide them by their land footprint. Companies can follow the guidance outlined in Section 6.1 to calculate their land footprint.

The calculation of emissions associated with land management has several methods available and data inputs required. Calculation options and data sources can be generalized using the 'tier' system provided in the IPCC Guidelines for National GHG Inventories, as summarized by the (draft) GHG Protocol LSRG (2022):

- Tier 1 methods use global default emission factors and activity data on average land management practices.
- Tier 2 methods use country-level or geographically specific emission factors and activity data on average land management practices specific to those regions.
- Tier 3 methods use directly monitored emissions, modelled emissions or site-specific (derived from actual measurements) emission factors and activity data specific to the adopted land management practice.

A company may choose to adopt Tier 1, 2 and 3 methodologies based on its data availability. In line with the (draft) GHG Protocol LSRG (2022), companies should note:

- Tier 1 emission factors tend to be conservative, leading to overestimation of emissions based on global uncertainty ranges.
- Tier 2 emission factors and activity data are more specific to regions of origin and can reduce uncertainty relative to Tier 1 estimates.
- Tier 3 methods and data are based on actual monitoring or modelling of emissions and activity data from the actual land management practices and provide the highest level of accuracy that can best capture land management emissions and associated improvements or mitigation activities on relevant lands.

Companies may not have access to data at a higher Tier (2-3) due to commercial sensitivity of data, lack of direct measurements and high cost of sourcing the data (Stockholm Environment Institute and Climate and Clean Air Coalition, 2022).

Those that have set SBTi or SBTi FLAG targets and/or already report GHG emissions in line with the GHG Protocol should already have compiled activity data that can be used to calculate these non-GHG emissions associated with land management, such as fertilizer type and quantity applied, livestock numbers, and mobile and stationary machinery use.

For companies engaged in the SBTN target setting process, during Step 1 they will have assessed their pressure on soil pollution if deemed material in the screening exercise. The data collected as part of this assessment, such as applied nitrogen, can also be used as part of the activity data needed to calculate nitrogen emissions in line with these guidelines. Additional data may be required depending on the level of data compiled for GHG emissions accounting and the methodology followed to calculate $NH_3$, $NO_X$ and $SO_2$ emissions.

The EMEP/EEA air pollutant emission inventory guidebook (European Environment Agency, 2023) provides widespread methods and is used to establish national air pollutant emission inventories. At the time of writing these guidelines, the latest update of the methodology was 2023 (European Environment Agency, 2023).

Furthermore, the Global Atmospheric Pollution Forum's Air Pollutant Emission Inventory Manual (Vallack and Rypdal, 2019) provides a framework for emission inventory preparation suitable for use in developing and rapidly industrializing countries that is compatible with the EMEP/EEA guidebook and IPCC Guidelines[5]. At the time of writing, the latest version of the Manual was Version 6.0.

In response to the lack of guidance for companies providing comprehensive and consistent guidance to develop for air pollutant emission inventory development, the Stockholm Environment Institute and Climate and Clean Air Coalition (2022) published A Practical Guide for Business Air Pollutant Emission Assessment.

It is recommended that companies follow the EMEP/EEA (European Environment Agency, 2023) guidance, Global Atmospheric Pollution Forum Manual (Vallack and Rypdal, 2019) and Stockholm Environment Institute and Climate and Clean Air Coalition guide (2022) or similar credible methods to calculate $NH_3$, $NO_x$ and $SO_2$ emissions. Where updates to methods and guidance are provided following the publication of these guidelines, companies should strive to align with the most up-to-date methods.

[5] The Global Atmospheric Pollution Forum Air Pollutant Emission Inventory Manual Version 6.0 is compatible with other major emissions inventory preparation approaches such as those described in the 2016 EMEP/EEA air pollutant emission inventory guidebook (EMEP/EEA, 2016) and Intergovernmental Panel on Climate Change (IPCC) Guidelines for National Greenhouse Gas Inventories (IPCC, 2006).

## Calculate land management emissions

To calculate $NH_3$, $NO_X$ and $SO_2$ emissions, companies calculate emissions associated with land management activities. Depending on the company, its value chain position and associated sector, emissions may include the following sources:

- Energy use e.g. energy use associated with manufacturing and construction and fuel usage of off-road machinery such as tractors
- Industrial processes and product use
- Agriculture e.g. synthetic and organic fertilizers applied to soils and manure management

When compiling emissions data, companies should follow the guidance set out in Chapter 3 on data types, data selection, data traceability and data quality.

At a high-level, emissions can be estimated using the following equation that relies on activity data and default emission factors that represent typical or average process conditions:

*Emissions = Emission factor x Activity*

Emission factors provide the emissions per unit activity, for example kg $NO_x$ emitted per TJ fuel consumed. Abatement of emissions can be considered by applying a technology-specific emission factor or by subtraction in line with the following equation:

*Emissions = Emission factor x Activity rate – Abatement/Recovery*

Some methods are more complex and include more than one emission factor or type of activity data. Examples include emission sources in the agriculture or transportation sector (Vallack and Rypdal, 2019). More detailed emission factors can be used that integrate information on process conditions, fuel quality, and other specificities of the process being quantified (Stockholm Environment Institute, 2022).

Default emission factors are provided in the EMEP/EEA Guidebook and Global Air Pollution Forum Manual. To improve impact calculation, companies are encouraged to source more granular, regional information and data where feasible. For example, from peer reviewed literature, national/regional research organizations or industry organizations.

Table 20 summarizes the method and data needed to calculate emissions at a sector and sub-sector level, adapted from the Stockholm Environment Institute (2022) and EMEP/EEA (2023) guidebook. This table provides the key sub-sector sources of $NH_3$, $NO_X$ and $SO_2$ emissions relevant to companies as well as a summary of the methods and data inputs required. The methods and data are limited to Tier 1 and Tier 2 approaches.

**Please note, the table and examples are non-exhaustive. They aim to provide examples of data and methodological considerations for different sources and sub-sources of emissions**. **When calculating emissions, companies should directly consult the EMEP/EEA Guidebook, Global Air Pollution Forum Manual, Stockholm Environment Institute and Climate and Clean Air Coalition Guide or other similar credible methods and guidance**.

As outlined in Chapter 4, allocation of impacts may be required. Companies should follow the guidance in Chapter 4 to implement an appropriate allocation approach where relevant.

**Table 20 Summary of calculation methods and data inputs for sector and sub-sector sources (non-exhaustive) of $NH_3$, $NO_X$ and $SO_2$ emissions (adapted from Stockholm Environment Institute and Climate and Clean Air Coalition (2022) and the European Environment Agency (2023))**

| Source | Sub-source | High-level method | Tier 1 data inputs* | Tier 2 data inputs* |
|---|---|---|---|---|
| Agriculture | Manure management | • Estimate the number of livestock animals disaggregated by livestock category (e.g. dairy cattle, pigs) and where manure is typically handled as solid or slurry.<br>• The total number of specific type of livestock under the different manure type (e.g., dairy cattle, slurry) is multiplied by an emission factor, specific to the type of livestock, manure type and manure management system. | • Number of livestock in each livestock category.<br>• Type of manure per livestock category (e.g. solid, slurry, outdoor).<br>• Pollutant specific emission factor by livestock category and manure handling type. | • Number of livestock in each livestock category.<br>• Type of manure per livestock category.<br>• Time spent in different locations (grazing, yard, housing).<br>• Nitrogen excretion rate (default values available).<br>• Pollutant specific emission factor by livestock category and manure handling type and management system. |
| | Synthetic fertilizer, organic fertilizer and crop residue application to fields | • Calculate land footprint for each type of crop.<br>• The land area for each type of crop is multiplied by the amount of nitrogen applied in fertilizer, organic waste or crop residues which is then multiplied by a pollutant specific emission factor. | • Metric tons of product produced and yield or area of land per crop type.<br>• Amount of nitrogen applied in fertilizer, organic waste or crop residues.<br>• Pollutant specific emission factor. | • Area of soil above or below pH 7.0.<br>• Crop specific nitrogen fertilizer application rate.<br>• Fertilizer specific emission factors for soil pH types and pollutants.<br>For crop residues<br>• Area per crop type.<br>• Harvested fresh yield of crop.<br>• Dry matter fraction of harvested crop*.<br>• Ratio of above ground residue dry matter to harvested yield*.<br>• Nitrogen content of above-ground residue per crop*.<br>• Fraction of the crop residues that produce $NH_3$ emissions per crop. |

| | | | | |
|---|---|---|---|---|
| | | | | *Default values available in EMEP/EEA Guidebook |
| | Field burning of agricultural residues | • Calculate land footprint for each type of crop.<br>• The area burned is multiplied by a pollutant specific emission factor to estimate air pollutant emissions. | • Area of land on which crops are grown whose residues are burned.<br>• Average crop yields*.<br>• Ratio of mass of crop residues and crop yield and crop yield*.<br>• Dry matter content of yield*<br>• Proportion of those residues that are burned*<br>• Combustion factor*<br>• Pollutant specific emission factor<br>*Default values available in EMEP/EEA guidebook. | As per Tier 1 with addition of:<br>• Dry weight per ha yield of specific crops.<br>• Technology-specific emission factor for pollutants. |
| **Energy** | Combustion in manufacturing and construction industries | • The fuel consumed by a specific technology is multiplied by the emission factor for the specific technology and pollutant.<br>• Presence of abatement technology. | • Fuel consumed<br>• Emission factor specific to pollutant | • Fuel consumed<br>• Emission factor specific to pollutant, category and fuel type<br>• Abatement technology (if present)<br>Variables need to be category, technology and fuel specific |
| | Non-road machinery (e.g. off-road vehicles and other machinery used in agriculture and forestry; mobile combustion in | • The total amount of non-road vehicles is disaggregated by machinery type, fuel type and engine.<br>• The amount of non-road vehicles disaggregated by machinery type, fuel type and engine type is then multiplied by a machinery-, fuel-, engine- specific | • The total amount of non-road vehicles.<br>• The percentage of the different types of machinery type.<br>• The percentage of fuel type and engine for each type of machinery. | • The total amount of non-road vehicles<br>• The percentage of the different types of machinery type<br>• The percentage of fuel type and engine for each type of machinery<br>• The age of the different types of machinery disaggregated by fuel and engine type |

| | | | | |
|---|---|---|---|---|
| | manufacturing industries and construction) | air pollutant emission factor to estimate air pollutant emissions. | | |
| **Industrial Processes and Product Use** | Mineral products<br>Chemical industry<br>Metal production<br>Other industry production | • Activity data on the production of each category is multiplied by an emission factor for each pollutant.<br>• Presence of abatement technology.<br>*Note: emissions associated with combustion are not included in this category as are covered under Energy.* | • The annual production of the category.<br>• Pollutant specific emission factor. | • The annual production rate of the category using the specific technology within the source category.<br>• Abatement technology (if present).<br>• Technology and pollutant specific emission factor. |

*Default emission factors are provided in the EMEP/EEA Guidebook

### Step 2 Match inventory data with characterization factors

Once companies have calculated their emissions of $NH_3$, $NO_X$ and $SO_2$ (in kg/ha) for each production unit for the assessment year they will need to match the inventory data with the corresponding characterization factor. The characterization factors vary by emissions gas and location, and are available at different levels of granularity (country, sub-country, ecoregion and via GIS mapping) to support companies with varying levels of traceability and data accessibility [*placeholder for final characterization factor dataset link*].

It is recommended that companies use the GIS maps provided to select the relevant characterization factor due to increased accuracy. Companies will need to collate spatial data on production units in direct operations and overlay these with the GIS maps provided [*placeholder for link to GIS maps*] to select the appropriate terrestrial acidification characterization factor.

For companies that do not have GIS capabilities, they may use ecoregions, sub-country and country-level characterization factors, in that order of priority.

### Step 3 Calculate impact

Once companies' inventory is aligned with the data input requirements for the characterization factors, i.e. $NH_3$, $NO_X$ and $SO_2$ emissions per location, they multiply their inventory by the corresponding characterization factors (in kg$SO_2$-eq/kg) to calculate terrestrial acidification for each production unit.

**Table 21 Example baseline terrestrial acidification**

| Ecoregion | Ecoregion Example |
|---|---|
| **Commodity** | **Sugarcane** |
| **Inventory data (kg/ha)** | 18.3 kg $NH_3$ \| 13.2 kg $NO_X$ \| 2.9 kg $SO_2$ |
| **Ecoregion Acidification Factors (kg SO2-eq./kg)** | 1.37 kg SO2-eq./kg NH3 \| 0.15 kg SO2-eq./kg NOx\| 0.50 kg SO2-eq./ SO2. |
| **Acidification potential (kg$SO_2$eq/ha)** | 28.4 Total (25 $NH_3$, 1.9 $NO_X$, 1.5 $SO_2$) |

## 6.4 Implementing response options

The guidelines provide preliminary methods for direct operations to calculate a change in land quality values resulting from the implementation of select response options in direct operations. This is an initial effort that anticipates more comprehensive SBTN Step 4: Act guidance.

Response options for the purpose of these guidelines are actions that a company could take to improve the state of nature on land that would likely be reflected in the indicator used to measure its land impacts (e.g., land footprint, SOC, soil erosion and terrestrial acidification).

A non-exhaustive, draft list of possible response options that companies could consider in their efforts to reduce and/or improve their land impacts is provided in Annex 2. It builds on previous work by SBTN Land Step 3:

Measure, Set, & Disclose: Land (Version 1.0) that compiled an original list of response options classified to the AR3T Framework.

There are two approaches that companies can use to capture the impact of implementing a response option in their inventory under the activity assessment approach:

- The change is reflected in the inventory
- The change is reflected in the LEAF

Details on these preliminary methods and a decision tree for selecting the appropriate method are provided in Annex 2. For any response option assessed, companies should consider potential changes in yield - as they could reduce their impacts per hectare but increase their land footprint.

The response options provided and calculation guidance are limited to direct operations. Both are intended to provide a starting point for companies as there may be additional response options that can be implemented and measured to reduce impacts on the SBTN impact categories.

# Chapter 7. Landscape Engagement

# 7.0 Calculation guidelines for landscape engagement

The intention of landscape engagement is to enable regenerative, restorative, and transformational actions in landscapes. In line with the Accountability Framework initiative (2024), these guidelines define a landscape initiative as a multi-stakeholder initiative in a given landscape to set common goals, take collective action, and monitor progress towards improving social, environmental, and economic outcomes, while reconciling different interests at a landscape level[6].

## 7.1 Selecting metrics to baseline and measure progress at a landscape level

For companies setting an SBTN Landscape Engagement target, the (draft) Step 3: Land (Version 2.0) technical guidance outlines the approach for companies to identify and prioritize landscapes for engagement in a materially relevant place - detailed guidance is provided in section 3 of the (draft) Step 3: Land (Version 2.0) technical guidance including a landscape maturity matrix. These guidelines outline the approach for companies to set baselines and measure progress on selected landscapes for engagement.

Companies seeking to engage in landscape initiatives should work collaboratively with the initiative's stakeholders to baseline and measure progress based on selected ecological and social metrics. The selected metrics should be based on the needs of specific locations and through collaboration with stakeholder groups involved in the initiative. This ensures that companies target action at key issues tailored to the local context.

Companies seeking to engage in landscape initiatives can follow published good practice guidance such as that developed by ISEAL (2024), ISEAL (2022), LandScale (2021), Jurisdictional Approaches Resource Hub and Proforest (2022) that provide companies with guidance for effective investment and action in landscapes. The guidance provided acts as a foundation for companies to develop and participate in targeted, impactful and credible landscape initiatives. Companies will need to tailor guidance to the context and needs of the landscapes within which it seeks to engage.

### 7.1.1 Select indicators and metrics

SBTN acknowledges the variety of indicators, metrics, and indexes that can be used to assess ecological and social conditions in landscapes. Selected metrics must reflect the baseline and performance at the landscape level and be identified through multi-stakeholder collaboration to provide direct or proxy information about progress towards the defined goals and targets of the landscape initiative.

Several commonly used landscape assessment frameworks are available to support companies in the identification and measurement of landscape metrics, such as LandScale Assessment Framework, Restoration Opportunities Assessment Methodology (ROAM), and Landscape Reporting Framework from the Consumer Goods Forum as well as ongoing work on the State of Nature Metrics by the Nature Positive Initiative.

[6] **Note for consultation:** there is a need to accommodate a greater diversity of values into decision-making through the framework of nature's contributions to people (NCP). NCP is an area that remains under review and engagement with experts by SBTN.

Measurable performance improvements at the landscape level can take time, and as such can be supplemented by metrics based on more granular, project-level interventions. In line with ISEAL (2022) guidance, metrics that assess performance improvements should:

- Measure the status or trends in a specific sustainability outcome.
- Be standardized and applied consistently to facilitate comparability of findings over time. This is also a prerequisite for aggregating data from multiple actors in a landscape.
- Align with existing landscape or jurisdictional metrics, linking the monitoring with that of the states and municipalities within the landscape or jurisdiction.
- Be sensitive enough to detect relevant changes from a baseline state.
- Be consistent with SMART guidelines (i.e. specific, measurable, attainable, relevant, and time-bound) so that they can be objectively measured.
- Be cost efficient and not overly complex, recognizing that in some cases, more costly or specialized data might provide more reliable results.
- Be defined in quantitative terms but supplemented by qualitative information when appropriate.

Companies should ensure that metrics are relevant to the landscape in which they are applied. However, consistency of metrics across landscapes is also useful for stakeholders outside the landscape to enable comparability of progress. The decision on selected metrics should be driven through a multi-stakeholder process and prioritized based on practical constraints such as budget and data availability. In line with ISEAL (2022) guidance, companies could develop a suite of metrics consisting of:

- A core set of broadly applicable across landscapes and consistent with what is measured elsewhere. These can be drawn from existing measurement frameworks such as LandScale (a leading initiative that aims to provide a framework to define landscape-level metrics).
- Metrics that are relevant to the landscape, based on the particular ecological or socioeconomic context.
- Metrics that are defined locally by stakeholders based on where they determine is important to them.

The LandScale Assessment Framework (2021) provides four categories of indictors that seek to represent the condition and processes within the landscape that are indicative of performance related to the selected goals linked to the following pillars: ecosystems, human well-being, governance, and production. The measurement of indicator performance is provided by quantitative or qualitative performance metrics. An example is provided in Table 22.

**Table 22 Example landscape indicator and performance metric (adapted from LandScale, 2021)**

| Indicator | Description | Performance metrics |
|---|---|---|
| **Biodiversity habitat restoration** | Restoration of ecosystems in areas identified as important for biodiversity | Area (ha) and percentage (%) of land under restoration within areas identified as important for biodiversity |

The LandScale approach allows for a degree of adaptability in a landscape initiative's choice of metrics, building on priorities and available capacities. Companies may use the LandScale assessment framework as a basis for identifying and structuring relevant indicators and metrics for their selected landscape initiative.

### 7.1.2 Establish the baseline condition of selected landscapes

Companies need to establish the performance baseline of the landscape based on the selected metrics and indicators. This is essential to establish a reference point against which performance will be measured. Companies should ensure that a baseline assessment considers the following:

- **Sustainability scope:** The selected indicators and metrics based on the identified needs of the landscape.
- **Geographic scope:** This should be aligned with the landscape or jurisdictional boundary. Where relevant datasets are only available at other scales, e.g. national or sub-national, performance should be extrapolated to the landscape scale if possible.
- **Date of baseline:** The baseline needs to represent performance at a point in time.
- **Consistency of data**: The datasets that are used in the baseline assessment should be those that will be updated and available over time so there is consistency in the data that is collected from year to year, enabling a comparison in change over time.
- **Reconciling multiple baselines:** Multiple baselines are likely to exist at different scales within the landscape, e.g., from existing projects or government agencies. These baselines should be reconciled to the extent possible, seeking to align metrics, measurement methods, and datasets. For local acceptance and ownership, it is important to align with pre-existing public data such as national or sub-national datasets.

| Example accounting approach for a company engaging in an existing landscape initiative |
|---|
| <u>**A company joins an established landscape initiative**</u><br>Based on an assessment of its value chain activities, an agri-food company identifies a materially relevant place to engage in a landscape initiative. Through engagement with local stakeholders, the company identifies an existing initiative that has been established with the core objectives of habitat conservation and increased species abundance. The project is managed collaboratively by local farmers, ecologists, and a community group.<br><br>The landscape is a Key Biodiversity Area, designated for its importance for local populations of a protected bird species . The initiative aims to restore 5,000 hectares of wildlife-rich habitat within the landscape over the next five years, with plans for maintaining improvements into the future and to increase the abundance of the protected bird species in the landscape. |

The company decides to join the initiative, contributing funding to expand the project's scope to 15,000 hectares. Given the initiative's twin objectives of habitat restoration and increased species abundance, the company and stakeholders agree on the following environmental metrics to baseline and monitor progress at the landscape level:

- Total area (ha) and percentage (%) of natural ecosystems in the landscape that are currently degraded
- Total area (ha) "under restoration" in the landscape
- Change in number of individuals of protected species

These metrics are derived from the performance metrics in the LandScale guidance and Nature Positive Initiative's Draft State of Nature Metrics. It is important for the company to adopt both area and non-area metrics to monitor its direct action (i.e. additional 10,000 hectares restoration) and to ensure progress is being achieved at the landscape level beyond where it is taking this direct action (i.e. through monitoring species abundance).

To establish a baseline for these metrics, the company undertakes the following steps in collaboration with the initiative's stakeholders:

**Metric 1: Total area (ha) and percentage (%) of natural ecosystems in the landscape that are currently degraded**
The purpose of this indicator is to evaluate the condition of natural ecosystems within the relevant landscape. Ecosystem condition refers to the overall state or health of an ecosystem. In this context, the metric requires companies to quantify both the total area and the proportion of the ecosystem that is classified as being in a 'degraded' state. This metric functions as an outcome indicator, as it measures the resulting condition of natural ecosystems and reflects the outcomes of actions taken. The condition of a habitat is a direct reflection of the health of the broader ecosystem.

There are several protocols available for assessing the condition of different habitats. The relevance of any protocol will be context specific. One option is to use protocols established for assessing the condition of protected sites. Protected sites are areas legally designated for their environmental or ecological significance. Many countries have established, science-backed methods for making these assessments, which are usually publicly available. For example, England and Canada, have developed their own national guidelines, and countries such as Thailand and China use the Management Effectiveness Tracking Tool for this purpose.

In this example, country-level guidance classifies the condition of habitats on a scale from 'unfavorable' to 'favorable' condition. To align with the chosen metric, any habitat classified as 'unfavorable' is considered degraded. To assess habitat condition, the project team establishes standardized protocols for conducting field surveys. These surveys involve on-the-ground measurements of various habitat characteristics, such as structural complexity, to make a quantified assessment of their condition. For instance, in a woodland habitat, a surveyor may record tree species diversity as one indicator of condition. The characteristics assessed differ across habitat types to ensure an accurate evaluation of their condition.

To maintain consistency and scientific rigor, the company adopts this protocol to establish a baseline for the additional 10,000 hectares of habitat restoration funded by its contribution. The condition of all relevant habitats within the landscape is assessed and mapped to effectively monitor this indicator. These habitat maps are created using ArcGIS (Geographical Information Systems), which is standard practice in the sector. There is a free version of this software called QGIS which could also be used. Creating these maps enables the company to visualize where different habitats present in the landscape are located, including the size of each habitat type and the condition of each habitat. These maps are usually created using aerial images of a site and overlaying habitat information. Using this approach, the company creates a spatial record of the baseline which can be used to report against this metric.

**Metric 2: Total area (ha) "under restoration" in the landscape**
This metric tracks the steps taken to enhance habitat condition. It is an action indicator as it measures the actions being taken and not the outcome those actions achieve.

Many government organizations and NGOs provide comprehensive signposting to guidance for restoring different habitat types across different landscapes and much of this guidance is publicly available. For example, management actions to increase the number of plant species in a grassland could include reducing the frequency of mowing and removing cut grass to prevent over nutrification. The project team uses government guidelines to inform its restoration plans, which the company adopts.

To establish a baseline for this metric, the company uses the maps developed using ArcGIS for Metric 1. Since no restoration activities have started in this area, the baseline is set at zero. All future actions to improve habitat condition will be recorded spatially to ensure accurate monitoring, as explained for Metric 1.

**Metric 3: Change in the number and proportion of priority species with: 1) stable or increasing populations, and 2) declining populations**

The baseline for this metric (summarized in the table below) is the number of individuals of the bird species present in the landscape when the company joins the scheme, based on data gathered by the landscape initiative team.

Methods used to assess species abundance include standardized methods of field survey for birds, point counts and transect walks. These surveys are performed on a bi-weekly basis and the results are tracked over time to identify positive or negative trends in the number of individuals present in the landscape.

**Species Population Abundance (adapted from (draft) Nature Positive Initiative, 2025)**

| Indicator | Metric |
|---|---|
| **Species Population Abundance** | Change in the number and proportion of priority species with: 1) stable or increasing populations, and 2) declining populations |

These data align with the information required for the (draft) Nature Positive Initiative metric which tracks the change in the number and proportion of priority species with 1) stable or increasing and 2) declining populations.

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# Annexes

# Annex 1 Land use change

## Annex 1a Conversion-driving commodities

| Soft commodities | Sources |
|---|---|
| **Cattle** | Multiple sources |
| **Cocoa** | Multiple sources |
| **Coffee** | Hoang, 2021 |
| **Oil palm** | Multiple sources |
| **Rubber** | Multiple sources |
| **Soybeans** | Multiple sources |
| **Timber/wood fiber** | Multiple sources |
| **Avocados** | Dryad, 2020 |
| **Banana** | Meyfroidt, 2014; Jayathilake, 2021 |
| **Beans** | Phalan, 2013 |
| **Buckwheat** | Plowprint, 2022 |
| **Camelina** | Plowprint, 2022 |
| **Canola** | Plowprint, 2022 |
| **Cassava** | Phalan, 2013; Jayathilake, 2021; Pendrill, 2022 |
| **Charcoal, commercial** | Jayathilake, 2021 |
| **Coconut** | Dryad, 2020; Jayathilake, 2021 |
| **Cotton** | Dryad, 2020 |
| **Cowpeas** | Phalan, 2013 |
| **Grapes** | Plowprint, 2022 |
| **Groundnut** | Phalan, 2013 |

| Soft commodities | Sources |
|---|---|
| **Maize** | Multiple sources |
| **Millet** | Phalan, 2013 |
| **Mustard** | Plowprint, 2022 |
| **Onions** | Plowprint, 2022 |
| **Pineapple** | Meyfroidt, 2014 |
| **Potato** | Plowprint, 2022 |
| **Radishes** | Plowprint, 2022 |
| **Rice** | Multiple source |
| **Rye** | Plowprint, 2022 |
| **Safflower** | Plowprint, 2022 |
| **Sorghum** | Phalan, 2013 |
| **Speltz** | Plowprint, 2022 |
| **Sugarcane** | Phalan, 2013, Dryad, 2020 |
| **Sugar beets** | Plowprint, 2022, Dryad, 2020 |
| **Tobacco** | SBTN HICL, 2022 |
| **Triticale** | Plowprint, 2022 |
| **Vetch** | Plowprint, 2022 |
| **Wheat** | Multiple sources |

| Hard commodities | Sources |
|---|---|
| **Bauxite** | Luckeneder, 2021 |
| **Coal, surface mining** | Yu, 2018 |
| **Copper** | Luckeneder, 2021 |
| **Gold** | Luckeneder, 2021 |
| **Iron** | Luckeneder, 2021 |
| **Lead** | Luckeneder, 2021 |
| **Manganese** | Luckeneder, 2021 |
| **Nickel** | Luckeneder, 2021 |
| **Palladium** | SBTN HICL, 2022 |
| **Platinum** | SBTN HICL, 2022 |
| **Silver** | Luckeneder, 2021 |
| **Zinc** | Luckeneder, 2021 |

| Activities/applications | Sources |
|---|---|
| **Biofuels (ethanol, solid biomass, etc.)** | Multiple sources |
| **Feed for animal protein – cattle, pork, chicken, aquaculture, etc.** | Multiple sources |
| **Urban/settlement and infrastructure development** | Jayathilake, 2021 |
| **Hydroelectric dam development** | WWF, Deforestation Fronts, 2021 |
| **Oil and gas exploration** | Jayathilake, 2021 |

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## Annex 1b First point of aggregation

The data requirements for accounting for land use change differ based on a company's value chain position(s) and proximity to the site of soft commodity harvest/production or hard commodity extraction (e.g., "the cradle" in life cycle assessment terminology). While "producers and site owners/operators" are clearly defined, as they own and/or operate the land where production/harvest and extraction occur, companies sourcing from producers and from the "first point of aggregation" are less defined.

We understand that not all companies at the first point of aggregation have traceability for all supply chains at this time— the intention is for this to be a stretch goal for companies to implement over time. Increased transparency at the front end of supply chains will benefit companies further down the supply chain (closer to retail, consumers, and asset management) who can assess risk and take actions to align their supply chain with their stated goals. The table below defines SBTN's first point of aggregation for many conversion-driving commodities.

**SBTN's suggestion for first point of aggregation**

| Global conversion-driving commodities | First point of aggregation |
|---|---|
| Cattle | Meat packing and processing facilities, milk and dairy processing facilities |
| Cocoa | Refineries and grinders |
| Coffee | Processing (drying to grinding beans) |
| Maize | Wet and dry milling |
| Oil palm | Oil palm mill and collection port |
| Rice | Rice mill (cleaning and husking) |
| Rubber | Rubber dealer/first processing |
| Sorghum | Milling |
| Soybeans | Crushing facilities |
| Sugarcane | Sugar mills |
| Timber/wood fiber | Timber mill/pulp production facility |
| Wheat | Milling facilities |
| Biofuels (ethanol, solid biomass, etc.) | Depending on feedstock, align with first point of aggregation above by commodity |
| Feed for animal protein – cattle, pork, chicken, aquaculture, etc. | Feed mixing and pellet processing facility |

# Annex 1c How to consult the SBTN Natural Lands Map

## How to use the map to calculate conversion of natural ecosystems after 2020

This section provides guidance on how a company can consult the SBTN Natural Lands Map to calculate conversion of natural ecosystems based on direct measurements or statistical calculation of conversion. There are different prerequisites and associated pathways for companies at different stages of supply chains.

### Producers and project site owners and operators

Producers and project site owners/operators are required to collect data (as per Table 8) on their production units and recent conversion or land use change occurring after the 2020 baseline year.

With the data collected, companies can overlap the spatial data displaying recent conversion with the Map. The Map will allow a company to identify whether the conversion that occurred is of natural ecosystems or other non-natural land.

### Sourcing from producers or from first point of aggregation

Companies who are sourcing commodities and products driving conversion (Annex 1a) from producers or from the first point of aggregation (Annex 1b) are required to collect data (as per Table 8) on production units or sourcing areas.

When accounting directly for conversion through a production unit's spatial data, companies can consult the Map following the same procedure used by producers.

For a given sourcing area, all conversion attributable to a production unit can be assessed through the Map to understand the hectares of natural ecosystems converted.

Companies using data on sourcing areas must follow the accounting guidance for estimating the area converted using statistical land use change methods. For a given sourcing area, data on conversion must be retrieved. Allocation methods presented in the accounting guidance must be used to allocate responsibility of land use change to a given company.

Companies that have sourcing information only to subnational jurisdiction will use statistical land use change to estimate conversion

### Sourcing from downstream of the first point of aggregation

Companies who are sourcing commodities or products driving conversion downstream from the first point of aggregation are required to collect data (as per Table 8).

For volumes traceable to production units, companies can consult the Map using the same procedure defined for producers, site owners and operators.

For volumes traceable to sourcing areas, companies can follow the same procedure outlined for sourcing from producers or the first point of aggregation.

For volumes that are not yet traceable and/ or highly transformed, companies cannot use the Map to assess and quantify conversion of natural ecosystems.

# Annex 2 Calculation guidelines for response options

There are two ways in which companies can capture the impact of implementing a response option in their inventory using an activity assessment approach:

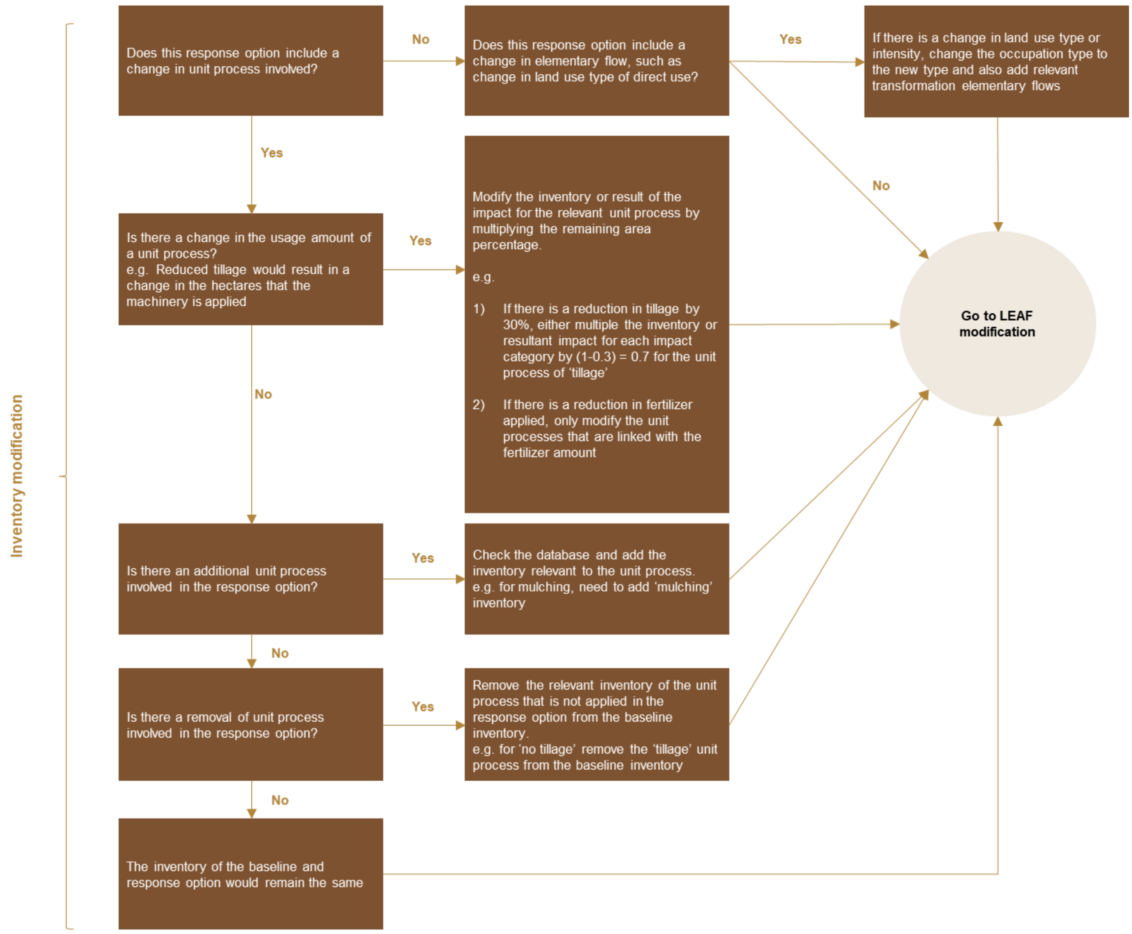
- **The change is reflected in their inventory**: companies can modify an inventory in three ways.
    - Changing the amount of applied unit processes: This involves modifying the original data given in the inventory for a certain unit process. This could result in changes in the extent of land use (in hectares), or the amount of fertilizer applied, or fuel emissions from machinery or vehicles. For example, in 'reduced tillage' there should be a reduction in the inventory linked with tillage, which might lead to reduced emission acidification due to fossil fuel combustion from machinery.
    - Addition/removal of unit processes involved within the baseline inventory*:* Depending on the response option, there could be a change in unit processes compared to the baseline practice. For example, going from full tillage to no-tillage would lead to removing the tillage unit process, eliminating fossil fuel acidifying emissions completely from this source.
    - Change in elementary flow*:* In some response options there is a change in the land use type or intensity (e.g. from grassland, intensive, to grassland, extensive), or gases emissions due to a response option.
- **The change is reflected in the LEAF**: In the LEAF matching step, companies change them to account for the response option. The change is applied in two potential ways:
    - To be in line with inventory changes*:* When there is a change in inventory, that could be related to land use intensity change, the matching LEAF should be used for impact quantification of the response option. For example, a company could go from intensive into extensive annual crop cultivation. In this case, the company should change the land use intensity category and calculate the new impact based on the new LEAF.
    - To measure the improvement in quality*:* This approach aims to quantify the potential improvement in environmental quality by considering regional differences when there is not an exact matching of LEAF for different land management types.. This requires shifting to the next smaller factor within the same land use type.
        - For example, consider an agricultural production in Argentina, where the initial practice matches with *'occupation, arable/annual, irrigated'.* The company implements a response option that improves SOC and soil erosion, but cannot directly quantify the improvement on both categories. To measure the impact of the response option, the LEAF of '*occupation, annual, non-irrigated, intensive'* and '*arable, irrigated, extensive'* should be applied – as summarized in the table below.
        - Since LEAF are spatially explicit, the change in applied factors for each response option need to be specific to the location of the activity.
        - For this modification, it should be kept in mind that for the response options related to grassland and pasture, if the next lower factor belongs to land use types under 'shrubland', they can be utilized. However, for some countries, LEAFs for these land use types, and their sub-classes are equal. Therefore, while the literature suggests that there could be an improvement, this may not always be quantifiable using LEAFs.

- The guidelines encourage companies to implement more precise methods and data where possible to capture the impact of implementing response options and only to use this calculation approach as a last resort.[7]

**Example of change in applied LEAF for response option assessment for 'alley cropping'**

| Soil organic carbon baseline | Soil organic carbon – response option | Soil erosion baseline | Soil erosion – response option |
|---|---|---|---|
| **Annual, irrigated** | Annual, non-irrigated | Arable, irrigated, intensive | Arable, irrigated, extensive |

An accompanying decision framework has been developed to support companies to calculate the change in impact associated with each response option.

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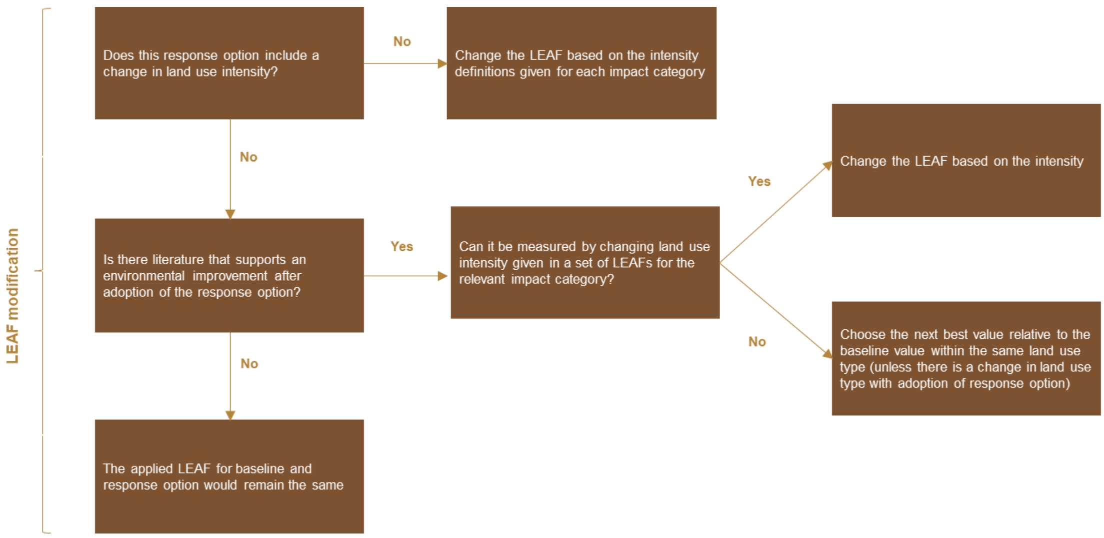
[7] **Note for consultation:** SBTN Land is working to develop examples of improvements for selected commodities and regions. A complete assessment of all combinations is not currently feasible. As such, SBTN Land is working to develop guidelines for companies to complete this assessment to calculate improvements where appropriate data exists.




**Decision tree for calculating the impact from the implementation of response options**

1 **Draft list of response options**

| # | Category | Name | Description | Relevant impact category | LEAF or inventory change |
|---|---|---|---|---|---|
| 1 | Biochar | Biochar soil application | Biochar is obtained by pyrolyzing biomass and is, by definition, applied in a way that avoids its rapid oxidation to $CO_2$. Its use in agriculture includes animal feeding, manure treatment (e.g. as additive for bedding, composting, storage or anaerobic digestion), fertilizer component or direct soil application. Because the feedstock carbon is photosynthetically fixed $CO_2$ from the atmosphere, producing and applying biochar is essentially a $CO_2$ removal (CDR) technology, which has a high technology readiness level. | Acidification | Inventory |
| | | | | SOC | LEAF |
| | | | | Yield | Inventory |
| 2 | Natural Forest Management | Reduced impact logging | Practices that avoid damage to non-commercial trees. | Occupation | LEAF |
| 3 | Improved Plantations | Extension of logging rotation | Extension of logging rotation lengths to maximize yield while increasing average landscape carbon stocks. | Occupation | LEAF |
| | | | | Acidification | Inventory |
| | | | | Yield | Inventory |
| 4 | Improved Plantations | Multi-species plantation systems | Across experimental and natural systems, more diverse plant communities often have higher primary productivity. This can be due to complementarity between different species, which can more effectively use resources together, or a higher likelihood of more productive species being present. | Occupation | LEAF |
| | | | | Acidification | Inventory |
| | | | | Erosion | LEAF |
| | | | | Yield | Inventory |
| 5 | Fire Management | Advance fire control practices in | Advance fire control practices in tropical moist forests such as fire breaks between pasture and forest edges. | Occupation | LEAF |
| | | | | Acidification | Inventory |

| | | | | | |
|---|---|---|---|---|---|
| | | tropical moist forests | | | |
| **6** | Conservation Agriculture | Cover crops in fallow periods | There is increased carbon sequestration in agricultural soils when additional crops are planted in the periods when the main crop is not growing. When legume crops are used, there is decreased emissions from fertilizer manufacturing resulting from a reduction in the use of inorganic fertilizer. | Acidification | Inventory |
| | | | | SOC | LEAF |
| | | | | Erosion | LEAF |
| | | | | Yield | Inventory |
| **7** | Conservation Agriculture | Reduced tillage | Increased sequestration in agricultural soils by adopting reduced- or no-till practices in croplands. | Acidification | Inventory |
| | | | | SOC | LEAF |
| | | | | Erosion | LEAF |
| | | | | Yield | Inventory |
| **8** | Conservation Agriculture | Zero tillage | Increased sequestration in agricultural soils by adopting reduced- or no-till practices in croplands. | Acidification | Inventory |
| | | | | SOC | LEAF |
| | | | | Erosion | LEAF |
| | | | | Yield | Inventory |
| **9** | Agroforestry | Windbreaks | Increasing the quantity of trees in croplands by introducing windbreaks (also called shelterbelts), alley cropping, and farmer managed natural regeneration (FMNR). | SOC | LEAF |
| | | | | Erosion | LEAF |
| | | | | Yield | Inventory |

| | | | | | |
|---|---|---|---|---|---|
| **10** | Agroforestry | Alley cropping | Alley cropping is defined as the planting of rows of trees and/or shrubs to create alleys within which agricultural or horticultural crops are produced. The trees may include valuable hardwood veneer or lumber species; fruit, nut or other specialty crop trees/shrubs; or desirable softwood species for wood fiber production. | Occupation | Both |
| | | | | Acidification | Inventory |
| | | | | SOC | LEAF |
| | | | | Erosion | LEAF |
| | | | | Yield | Inventory |
| **11** | Agroforestry | Farmer managed natural regeneration | Farmer Managed Natural Regeneration (FMNR) is a low-cost land restoration technique used to build resilience to climate extremes and combat poverty and hunger amongst subsistence farmers by increasing food and timber production. Started in 1983 in Niger, FMNR is a form of coppicing and pollarding, drawing on traditional practices and sensitive to local variations.<br>In FMNR systems, farmers protect and manage the growth of trees and shrubs that regenerate naturally in their fields from root stock or from seeds dispersed through animal manure. FMNR is a simple, low-cost method for farmers to increase the number of trees in the fields. | Occupation | LEAF |
| | | | | Acidification | Inventory |
| | | | | SOC | LEAF |
| | | | | Erosion | LEAF |
| **12** | Grazing | Legumes in Pastures | Increased sequestration in soils due to sowing legumes in planted pastures; restricted to areas where this would result in net sequestration. Also includes, where relevant, avoided emissions from fertilizer application to pastures. | Acidification | Inventory |
| | | | | SOC | LEAF |
| **13** | Grazing | Grazing Optimization | Increased soil sequestration by increasing grazing in locations that are understocked and decreasing grazing in locations that are overstocked. | Occupation | LEAF |
| | | | | Acidification | Inventory |
| | | | | SOC | LEAF |
| | | | | Erosion | LEAF |
| **14** | Grazing | | | Acidification | Inventory |

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| | | Management of vegetation/<br>Forage Improvement | Including improved grass varieties / sward composition and deep rooting grasses for increased productivity and nutrient management. | SOC | LEAF |
| | | | | Erosion | LEAF |
| | | | | Yield | Inventory |
| **15** | Cropland Nutrient Management | Rice Residue incorporation | Crop residues are a rich source of plant nutrients which are released in soil through microbial decomposition. As a result, returning crop residue to the soil rather than burning it helps to improve several soil quality parameters. The long-term sustainability of rice-wheat system (RWS) requires robust interventions such as recycling of rice straw (RS) to improve soil health and minimize environmental impacts. | Acidification | Inventory |
| | | | | SOC | LEAF |
| | | | | Yield | Inventory |
| **16** | Improved Rice Cultivation | Fertilizer management | Application of plant nutrients in optimum quantities, in the right proportions and at the right times for a specific crop's needs and agroclimatic conditions. | Occupation | LEAF |
| | | | | Acidification | Inventory |
| | | | | Yield | Inventory |
| **17** | Grassland Restoration | Grassland Restoration | Increased sequestration from restoring cropland to grasslands areas with limitations on agricultural production; grassland or, shrubland in places where those systems occurred historically. | Occupation | LEAF |
| | | | | Acidification | Inventory |
| | | | | SOC | LEAF |
| | | | | Erosion | LEAF |
| **18** | Agroforestry | Silvopasture | Trees in grazing land. | Occupation | LEAF |
| | | | | Acidification | Inventory |
| | | | | SOC | LEAF |

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| | | | | Erosion | LEAF |
| **19** | Land Management | Crop rotation | Crop rotations are planned sequences of crops over time on the same field. Rotating crops provides productivity benefits by improving soil nutrient levels and breaking crop pest cycles. Farmers may also choose to rotate crops to reduce their production risk through diversification or to manage scarce resources, such as labor, during planting and harvesting periods. | Occupation | Inventory |
| | | | | Acidification | Inventory |
| | | | | SOC | LEAF |
| | | | | Erosion | LEAF |
| | | | | Yield | Inventory |
| **20** | Land Management | Perennial cropping systems | Perennial crops are defined by their ability to be harvested multiple times throughout their lifespan and to stay alive for more than two years before needing to be replanted. Perennial grains may contribute to reducing erosion, avoiding carbon losses and reducing nutrient losses to water. Perennial grains can also capture nutrients deeper in soil when they are scarce thereby reducing farm costs and increasing the effectiveness of agricultural grain crops. | Occupation | Both |
| | | | | Acidification | Inventory |
| | | | | SOC | LEAF |
| | | | | Erosion | LEAF |
| | | | | Yield | Inventory |
| **21** | Cropland Nutrient Management | Nitrification inhibitors | An inhibitor is a compound added to a nitrogen-based fertilizer to reduce losses when the fertilizer is applied to the crop. By extending the time the active nitrogen component of the fertilizer remains in the soil as either urea-N or ammonium-N, an inhibitor can improve nitrogen use efficiency (NUE) and reduce environmental emissions. There are two main types of inhibitor that are added to nitrogen fertilizers: a) Urease inhibitors (UI), which inhibit the hydrolytic action of the urease enzyme on urea. b) Nitrification inhibitors (NI), which inhibit the biological oxidation of ammonium to nitrate. | Occupation | LEAF |
| | | | | Acidification | Inventory |
| | | | | Yield | Inventory |
| **22** | Conservation Agriculture | Strip tillage | Strip tillage is defined by the Conservation Technology Information Centre (CTIC) as a modification to a direct drilling system where disturbance of less than one third of the total field is cultivated (Reeder, 2000). Crop residue | Acidification | Inventory |
| | | | | SOC | LEAF |

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| | | | is removed from the cultivated strips and placed between rows with the seed then drilled into the strips, either in spring or autumn. | Erosion | LEAF |
| | | | | Yield | Inventory |
| 23 | Land Management | Shade-cover system | Shade influences the microclimate of the cocoa block through its effect on the wind, the relative humidity and the amount of solar radiation received by the cocoa trees. The micro-climate, in turn, influences the incidence of pests and diseases (Smithsonian Institute, Federation of Cocoa Commerce). | Occupation | LEAF |
| | | | | Acidification | Inventory |
| | | | | SOC | LEAF |
| | | | | Erosion | LEAF |
| | | | | Yield | Inventory |
| 24 | Land Management | Re-vegetation | Planting of vegetation cover to reduce erosion by wind and water (Rainforest Alliance). | Occupation | LEAF |
| | | | | Acidification | Inventory |
| | | | | SOC | LEAF |
| | | | | Erosion | LEAF |
| 25 | Land Management | Contour farming | Farming with row patterns that run horizontally around the hill as opposed to up and down the hill (USDA). | Acidification | Inventory |
| | | | | SOC | LEAF |
| | | | | Erosion | LEAF |
| | | | | Yield | Inventory |
| 26 | | Terracing | Terracing of steep areas to reduce erosion by wind and water (Rainforest Alliance). | Acidification | Inventory |

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| | Land Management | | | SOC | LEAF |
| | | | | Erosion | LEAF |
| | | | | Yield | Inventory |
| 27 | Land Management | Intercropping crops with varied root depths | Planting multiple crops with different rooting depths and soil uses to enhance soil quality and health (Rainforest Alliance). | Occupation | LEAF |
| | | | | Acidification | Inventory |
| | | | | SOC | LEAF |
| | | | | Erosion | LEAF |
| | | | | Yield | Inventory |
| 28 | Improved forest management | Silviculture / silvopasture | Controlling the establishment, growth, composition, health, and quality of forests and woodlands to meet the diverse needs and values of landowners and society such as wildlife habitat, timber, water resources, and restoration on a sustainable basis. Silviculture practices include thinning, harvesting, planting, pruning, prescribed burning and site preparation (USDA). | Occupation | LEAF |
| | | | | Acidification | Inventory |
| | | | | SOC | LEAF |
| | | | | Erosion | LEAF |
| 29 | Improved forest management | Maintain forest habitat composition | Maintain forest habitat components and stand structures as would be expected from naturally occurring processes (FSC). | Occupation | LEAF |
| | | | | Acidification | Inventory |
| | | | | SOC | Inventory |
| | | | | Erosion | LEAF |

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| | | | | Yield | Inventory |
| 30 | | Silvopasture | Practice of integrating trees, forage, and the grazing of domesticated animals in a mutually beneficial way. It utilizes the principles of managed grazing (USDA, TNC). | Acidification | Inventory |
| | | | | SOC | LEAF |
| | | | | Erosion | LEAF |
| 31 | | Range plantings (trees, grasses) | Establishment of adapted perennial or self-sustaining vegetation such as grasses, forbs, legumes, shrubs and trees to restore the original plant community, reduce erosion, improve water quality, and increase carbon sequestration, among other benefits (NRCS, TNC). | Occupation | LEAF |
| | | | | Acidification | Inventory |
| | | | | SOC | LEAF |
| | | | | Erosion | LEAF |
| 32 | Grazing | Forage improvement | Planting of native grasses and other forage plants that reduce enteric emissions in grazing cattle in grazing lands. | Occupation | LEAF |
| | | | | Acidification | Inventory |
| | | | | Erosion | LEAF |
| 33 | Grazing | Integrated pest management | IPM is a sustainable, science-based, decision-making process that combines biological, cultural, physical and chemical tools to identify, manage and reduce risk from pests. This approach employs pest management tools and strategies in a way that minimizes overall economic, health and environmental risks. | Occupation | LEAF |
| | | | | Acidification | Inventory |
| 34 | Grazing | Managed/ prescribed grazing | Managing grazing and/or browsing animals through a rotational or mob grazing system where animals are moved to fresh pasture frequently enough to allow pastures time to recover, e.g. adaptive multi-paddock (AMP) grazing (TNC, USDA). | Occupation | LEAF |
| | | | | Acidification | Inventory |
| | | | | SOC | LEAF |

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| | | | | Erosion | LEAF |
| **35** | Land Management | Integrated pest management | IPM is a sustainable, science-based, decision-making process that combines biological, cultural, physical and chemical tools to identify, manage and reduce risk from pests. This approach employs pest management tools and strategies in a way that minimizes overall economic, health and environmental risks. | Occupation | LEAF |
| | | | | Acidification | Inventory |
| **36** | Land Management | Hedgerow planting | Dense woody vegetation planted in a linear design to provide food and shelter for wildlife, protect water quality and create a field boundary (NRCS). | Acidification | Inventory |
| | | | | Erosion | LEAF |
| | | | | Yield | Inventory |
| **37** | Land Management | Maintaining field margins | A strip of permanent, non-crop vegetation established at the edge or around the perimeter of a field. Establishing field margins helps to manage harmful insect populations by providing habitat for their natural predators and, thereby reduces the need for pesticide applications (NRCS). | Acidification | Inventory |
| | | | | Erosion | LEAF |
| **38** | Improved Rice Cultivation | Rice stubble | Rice stubble and straw are managed in a sustainable way to mitigate greenhouse gas emissions, minimize environmental impacts, and improve soil quality.<br>Rice stubble is: 1. Not burned. 2. Allowed sufficient time (at least 3 weeks) for aerobic decomposition before wetting. | Acidification | Inventory |
| | | | | SOC | LEAF |
| | | | | Yield | Inventory |
| **39** | Quarry management | Quarry rehabilitation | Biodiversity management approaches and rehabilitation programs enable cement and concrete companies to become more nature positive by helping to restore degraded habitats and recover species at new quarry and plant sites. Management of temporary habitats is also important for supporting biodiversity during the quarry's operational phase and helping to maintain species populations so that they can have a more rapid recovery come restoration | Occupation | LEAF |
| | | | | SOC | LEAF |
| | | | | Erosion | Inventory |
| **40** | Quarry management | Biodiversity Management Plans | Biodiversity management approaches and rehabilitation programs enable cement and concrete companies to become more nature positive by helping to restore degraded habitats and recover species at new quarry and plant sites. Management of temporary habitats is also important for supporting biodiversity during the quarry's | Occupation | LEAF |
| | | | | Acidification | Inventory |

| | | | | | |
|---|---|---|---|---|---|
| | | | operational phase and helping to maintain species populations so that they can have a more rapid recovery come restoration | SOC | LEAF |
| | | | | Erosion | Inventory |
| 41 | Conservation Agriculture | Mulching | Mulching is a crucial agronomic practice involving the application of materials to the soil surface. This technique conserves water by enhancing the soil's water infiltration capacity, reducing soil erosion, and minimizing surface runoff. Mulching also increases topsoil temperature and fertility, alters microbial biomass, and improves soil quality, which in turn enhances seed germination, root production, and plant development, leading to higher crop yields even with low water input. Additionally, mulching boosts enzyme activity in the soil, creating favorable conditions for plant metabolism, while also suppressing weed infestation and reducing weed density and biomass. | Acidification | Inventory |
| | | | | SOC | LEAF |
| | | | | Erosion | LEAF |
| | | | | Yield | Inventory |