GOLD STANDARD FOR THE GLOBAL GOALS

Soil Organic Carbon Framework Methodology

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ACKNOWLEDGEMENT:

TREES*

1. Methodology Scope and Structure

The methodology presents requirements to quantify changes in greenhouse gas (GHG) emissions and soil organic carbon (SOC) stocks through the adoption of improved agricultural practices. Activities can achieve avoidance of emissions as well as sequestration of carbon in the soil, both which result in increased SOC content.

This SOC methodology is applicable for a broad range of activities, from small scale, low tech land use to industrialized, large scale land management, using a variety of SOC improvement approaches. As scientific knowledge of SOC impact or activities covered in this methodology continues to evolve, the methodology is not limited to a specific activity but provides flexibility to apply the most current and best-fit systems.

The SOC methodology provides three approaches for the quantification of SOC improvements for baseline and project scenario. This accommodates the reality that not all relevant measurements and parameters may be available to all projects and SOC activities.

1. Take on-site measurements to directly document baseline and project SOC stock levels
2. Use peer-reviewed publications to quantify baseline and project SOC stock levels
3. Apply default factors to quantify SOC changes, relating to the general methodology described in the IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2019) using tier 2 level approach whenever possible.

The SOC Framework Methodology structure (Figure 1) features a core Framework Methodology (this document) and activity-specific modules to be developed on an ongoing basis.

Figure 1: Basic Architecture of Framework Methodology and Activity Modules
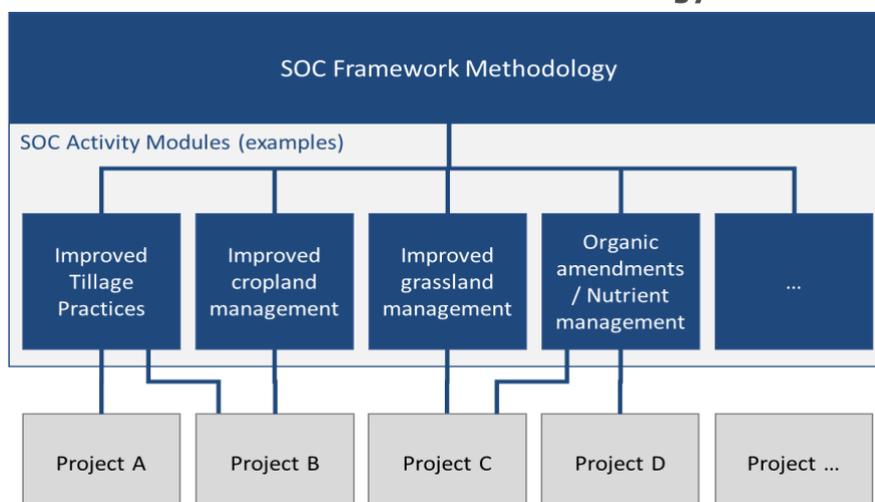
The **Framework Methodology** ensures that quality of projects and quantification of benefits correspond to the high level expected under Gold Standard for the Global Goals. The Framework Methodology:

- Defines requirements and guidance applicable to all activities
- Ensures quality and consistency across different activities, e.g. in quantification approaches and core equations
- Facilitates development of Activity Modules by defining a common basis and approach, as well as the overall requirements (which thus do not have to be repeated in the modules)
- Sets out rules to prevent benefit overlap if multiple Activity Modules are applied in a project

The **Activity Modules** are designed following the guidance provided in Framework Methodology. Activity Modules provide requirements and calculation approaches applicable to specific activities that increase SOC from baseline to project scenario. An Activity Module:

- Defines activity-specific applicability conditions, requirements and potential sub-selection of calculation approaches
- Presents activity-specific measurement and monitoring requirements
- May be globally applicable or be limited to specific conditions (e.g. soils, climate zones, data availability)
- May provide activity-specific data sources and/or models to apply (e.g. globally or regionally applicable parameters)

The methodology content differentiation between Framework Methodology and Activity Modules is described in more detail in
Table 1 below.

Project documentation will reference the Framework Methodology in combination with the applicable Activity Module(s). A project:

- applies one or more SOC Activity Modules for calculation of SOC accrual if the project activities are clearly delineated and benefits from SOC accrual do not overlap among project activities.
- specifies detailed impact calculations, including measurement and/or modelling approach, data sources and parameters used.

Table 1: Framework Methodology and Activity Modules content hierarchy

Sections	Framework Methodology	Activity Modules
Definitions and references	- Definitions of core terms - Overall references for SOC quantification	- Definitions of activity-specific terms - References for selected measurement and/or calculation approaches (models, parameters, datasets, key publications)

Applicability and requirements	• General applicability requirements for SOC Activities Modules	• Applicability requirements for specific activity, practices and/or quantification approaches (e.g. geographic limitations, additional requirements)
Project boundaries	• Requirements and guidelines to be applied at the Activity Module level for the delimitation of boundaries (spatial, temporal, carbon pools); general stratification criteria	• Activity-specific criteria for the selection and justification of boundaries (spatial, temporal, carbon pools) criteria (specific crediting period) • Specific criteria for project area stratification (relevant subset and/or additions to framework criteria)
Greenhouse Gases (GHG)	• List of eligible GHGs and criteria (if any) for inclusion and exclusion	• List of GHGs monitored for activity and justification for inclusion/exclusion of each
Approaches for the quantification of emission reductions (i.e. baseline and project emissions, leakage and other emissions)	• Core equations to consistently calculate impacts • Outline of the three eligible quantification approaches, including a decision tree to select applicable quantification approach(es) • List of potential sources of GHG emissions and removals to be accounted for under baseline, project, other emissions • Guidelines to identify and account for leakage	• Identification of quantification approach(es) applicable for baseline and project scenario • Detailed guidance and equations (or models) for selected quantification approach/es as well as key parameters • Any specific sources of GHG emissions and removals to be accounted for under baseline, project, other emissions, and leakage • Specific accounting of leakage and respective key parameters • Information on key parameters where customisation is being introduced (e.g. in the case of a regional application of an eligible project type)
Uncertainty assessment and contribution to Compliance Buffer	• Buffer Contribution and non-permanence requirements	• Any specific Buffer Contribution and non-permanence requirements

Additionality, sustainable development (SDG) contributions	• Reference to Gold Standard requirements on Additionality and SDG contributions	• Identification of default SDGs impacts
Monitoring	• Guidelines on eligible monitoring approaches	• Specific monitoring approach and key parameters

2. Definitions and References

2.1 Definitions

a. The definitions contained in the following documents apply:
   - Glossary of Gold Standard for Global Goals
   - Land-use & Forests Activity Requirements

b. For the purpose of this Framework Methodology and associated Activity Modules, the following specific definitions also apply:

Baseline:	Estimated soil carbon stocks in the baseline scenario.
Baseline scenario:	The activities that would occur in the absence of the proposed project (business-as-usual).
Calculation period:	The period between two points in time for which a change in carbon stocks is calculated, e.g. the time between project performance certifications.
Crediting period:	The time span in which SDG Impacts can be accounted for and are subject to monitoring.
Crop:	A plant or fungus species that is purposefully cultivated and/or harvested to satisfy human and livestock needs.
Crop residue:	Materials left in an agricultural field or orchard after the crop has been harvested. These residues include stalks and stubble (stems), leaves, and seed pods. Process residues are materials left after the crop is processed into a usable resource. These residues may include but are not limited to husks, seeds, bagasse, molasses and roots.

Cropping system:	The crops, crop sequences and the management techniques used on a particular field over a period of years.
Cropland:	All arable and tillage land and agro-forestry systems where vegetation falls below the threshold used for the forest land category, consistent with the selection of national definitions (IPCC, 2003).
Grassland:	Areas where the vegetation is dominated by grasses (Poaceae); however, sedge (Cyperaceae) and rush (Juncaceae) families can also be found along with variable proportions of legumes, like clover, and other herbs.
Land use change:	A change from one land use category to another.
Livestock:	All domestic animals. Non-domestic animals are not included unless they are kept or raised in captivity on agricultural holdings, including holdings without land (FAO, 1994).
Modelling Unit (MU):	Distinct areas with homogeneous characteristics to quantify a certain SDG Impact.
Monitoring period:	The period between two points in time for which a reduction in GHG emission is calculated, e.g. the time between project performance certifications.
Project region:	The spatial area where people and environment are influenced by the project activities. A project region can be expanded over time. All project areas are located within the project region.
Project scenario:	The scenario that will exist once the Project is implemented and operational.
Soil Organic Carbon (SOC):	Carbon (C) located in the Soil Organic Matter.
Soil Organic Matter (SOM):	Organic constituents in the soil such as tissues from dead plants and animals, products produced as these decompose and the soil microbial biomass.

Tillage:	The agricultural preparation of soil by mechanical agitation of various types, such as digging, stirring, and overturning.

2.2   References

- This Framework Methodology refers to and replaces the Gold Standard Agriculture Methodology for Increasing Soil Carbon Through Improved Tillage Practices V0.9 (released for road testing).
- In addition to the methodologies, methodological tools, guidelines, and key sources referenced herein, the Framework Methodology refers to other peer reviewed publications listed in Annex 2.

3.   Applicability

Projects shall comply with the applicability conditions specified in the Framework Methodology and in the respective applicable Activity Module. A project cannot apply the Framework Methodology without an applicable Activity Module.

The following conditions apply:

a. Geographic location:
   - Projects are eligible in all countries. SOC Activity Modules may limit geographic applicability.

b. Project area:
   - The project activity shall take place on the same parcel of land as the baseline.
   - Project area(s) shall not be on wetlands[1].
   - Project area (s) shall not be on forest according to the Land Use & Forests Activity Requirements (hereafter LUF Activity Requirements).

c. Site preparation:
   - No biomass burning for site preparation is allowed in the project scenario.
   - Project activities shall not include changes in surface and shallow (<1m) soil water regimes through flood irrigation, drainage or other significant anthropogenic changes in the ground water table.

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[1] Wetland: This category includes land that is covered or saturated by water for all or part of the year (e.g. peatland) and that does not fall into the forest land, cropland, grassland or settlements categories. Source: 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories – Glossary. https://www.ipcc.ch/site/assets/uploads/2019/12/19R_V0_02_Glossary.pdf /.

d. Land use:
- Managed cropping systems (e.g. single crop or crop rotation) must have been in place for at least 5 years prior to project implementation[2].
- The project activity shall not lead to land use change.[3]

e. Food security:
- No reduction in crop yield which can be attributed to the project activity shall be allowed. Activities in the project area shall deliver a yield at least equivalent to the baseline yield (five-year average, prior to project start). If regional crop productivity changes (e.g. due to climatic factors), yield in project area shall not decrease significantly (5%) more than yield in the project region.

4. Project Boundaries

4.1 Spatial boundary

The spatial boundary encompasses the impacts of activities that are under the project owner's control. Activities result in reduction of emissions and/or sequestration of carbon in the soil, which result in an increased SOC content in the project area.

Any areas leaving the project during the project duration, i.e. no longer included in monitoring, are conservatively considered full reversals (i.e. loss of all carbon sequestered). According to the LUF Activity Requirements the project owner is

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[2] If a SOC activity module considers a crop change between baseline and project scenario, the module shall contain evidence/calculation approaches that the change does not impact SOC stocks negatively in the medium term (e.g. 5 years) or specifically quantify the changes, considering at least the following parameters:
Direct impacts on SOC and project emissions:
- Agrochemical inputs, e.g. fertilizer or other nutrient inputs, pesticides, other additives
- Change in hydrology, e.g. due to irrigation, draining and seasonal shift in crop coverage
- Change in crop-related inputs, including plant residue and N-fixation
- Change in technical management of crop (e.g. machine use for planting, treatments and harvest)
- Seasonal change in crop management activities (e.g. harvesting, fallow periods, season without vegetation cover)

Market leakage risks
- Change in crop revenues (outside the normal market price variations)
- Change in crop yield (outside of normal variation) expressed in mass (tons) and with relation to calorific value and end user (crops for animal/human use)

[3] For activities involving land use change from grassland to cropland and vice-versa, contact the Gold Standard Secretariat

responsible to maintain or compensate carbon loss to the level of credits already issued according to the GHG Emissions Reductions & Sequestration Product Requirements. If new areas are added to the project, they have to be documented and certified according to the 'new area certification' procedures described in the LUF Activity Requirements.

4.2 Temporal boundary

According to LUF Activity Requirements the duration of the crediting period is specified on methodology level. SOC projects crediting periods shall be between 5-20 years. The Activity Modules shall define applicable crediting period length within this range based on published peer-review scientific results for a specific project activity addressing relevant SOC factors such as climate, soil type, etc.

For retroactive submission of projects and the respective crediting period please refer to the chapter Retroactive Issuance of the LUF Activity Requirements.

4.3 Carbon pools

This Framework Methodology focuses entirely on benefits from increase of soil carbon. Benefits accounting is thus limited to the soil organic carbon pool as shown in Table 2.

Table 2: Carbon pools to be included

Pools	Includes	Project	Baseline	Leakage
Above ground	Stem, branches, bark, grass, herbs, etc.	No	No	Yes*
Below ground	Roots of grass, trees, herbs	No	No	Yes*
Deadwood	Standing and lying deadwood	No	No	No
Litter	Leaves, small fallen branches	No	No	No
Soil organic carbon	Organic material	Yes	Yes	Yes
Wood products	Furniture, construction material, etc.	No	No	No

* change in biomass carbon stocks in leakage area to be accounted for in case of activity shift (see Section 11)

4.4 Greenhouse gases

The primary greenhouse gas monitored with all SOC project activities is CO_2. Monitoring of additional gases such as methane (CH_4) or nitrous oxide (N_2O) may be required in the respective Activity Modules (e.g. due to risk of leakage or change in fertilization). In principle, projects shall monitor all GHG sinks and sources affected by its activities. Exclusions may be made for impacts with limited measurability (i.e. quantifiability and data availability) if the omission is conservative, i.e. does not lead to overestimation of emission reductions or GHG

sequestrations. Also, GHG emissions considered insignificant (less than 5% of total emission reduction and sequestration) may be omitted from monitoring.

5.   Emissions Reduction Quantification Approaches

Greenhouse gas benefits from activities are calculated as the net changes in the soil organic carbon pool as defined below by **Equation 1** (below). Consequently, the CO_2 equivalent to the increase in SOC minus project emissions and potential emissions leakage effects is considered the greenhouse gas benefit attributable to the project activity. Projects shall transfer a fixed percentage of the issued GS VERs attributable to SOC sequestration activities into Gold Standard Compliance Buffer[4] according to the GHG Emissions Reductions & Sequestration Product Requirements. A contribution to Gold Standard Compliance Buffer is not required from activities involving SOC emission reductions (i.e. BUF = 0%).

$$ER_{t-0} = \left[\left(\Delta C_{SOC,t-0} \times \frac{44}{12} \right) - PE_{t-0} - LK_{t-0} \right] \times (1 - BUF) \tag{1}$$

Where:

ER_{t-0} = *emissions reductions to be issued for the calculation period [tCO2e]*

$\Delta C_{SOC,t-0}$ = *change in carbon stocks in mineral soils in the calculation period [tC]*

$\frac{44}{12}$ = *CO_2 to C molecular mass ratio [tCO2e tC-1]*

PE_{t-0} = *additional emissions due to project activity in the calculation period [tCO2e]*

LK_{t-0} = *leakage of emissions due to project activity in the calculation period [tCO2e]*

BUF = *compliance buffer fraction5 [dimensionless].*

Changes in SOC between two points in time (calculation period) are determined as the difference between SOC stocks at each point as defined by **Equation 2:**

$$\Delta C_{SOC,t-0} = (SOC_t - SOC_0) \times (1 - UD) \tag{2}$$

Where:

$\Delta C_{SOC,t-0}$ = *change in soil organic carbon stocks in the calculation period [tC]*

SOC_0 = *soil organic carbon stock at the beginning of the calculation period [tC]*

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[4] Refer to Gold Standard for Global Goals - GHG Emissions Reductions & Sequestration Product Requirements. https://globalgoals.goldstandard.org/500-gs4gg-ghg-emissions-reductions-sequestration-product-requirements/

[5] *Ibid.*

SOC_t = *soil organic carbon stock at the end of the calculation period [tC]*

UD   = *uncertainty deduction [dimensionless]*

Note: For the first calculation period, SOC0 is equal to SOCBL (see Section 6.1); for subsequent periods, SOC0 refers to the previous period's SOCt.

## 5.1 Approaches for baseline and project scenario quantification

To accommodate the reality that soil measurements are not always available to projects, especially for small community-based activities, this methodology incorporates three approaches to baseline and project activity quantification:

- *Approach 1:* Requires on-site measurements to directly document baseline and project SOC stocks.

- *Approach 2:* Uses calculation approaches, datasets, parameters and/or models from peer-reviewed publications to estimate baseline and project SOC stocks. Project owners need to prove that the research results are conservative and applicable to the project site and management practice.

- *Approach 3:* Applies default factors to estimate SOC changes, relating to the general Tier 1/2 model described in the IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2019). If possible, the Tier 2 approach as outlined in the IPCC Guidelines should be applied. Applicability of SOC reference values (SOC$_{REF}$) to be used in connection with IPCC impact factors shall be transparently demonstrated for the project area.

    Note that not all of the above approaches may be applicable to all SOC activities under this Framework Methodology. Specifically, datasets and/or models derived locally may only be applied if validated by direct measurements in the project area (Approach 1). Activity modules must define which approaches are applicable for the respective SOC activity. This selection will be assessed by the Gold Standard Secretariat at the time of module review.

Generally, project owners shall select the most specific approach possible with the data available, giving preference to local data sources and models. A decision tree to determine an eligible approach is illustrated in Figure 2 below. Further requirements for each approach are given in the baseline and project scenario chapters.
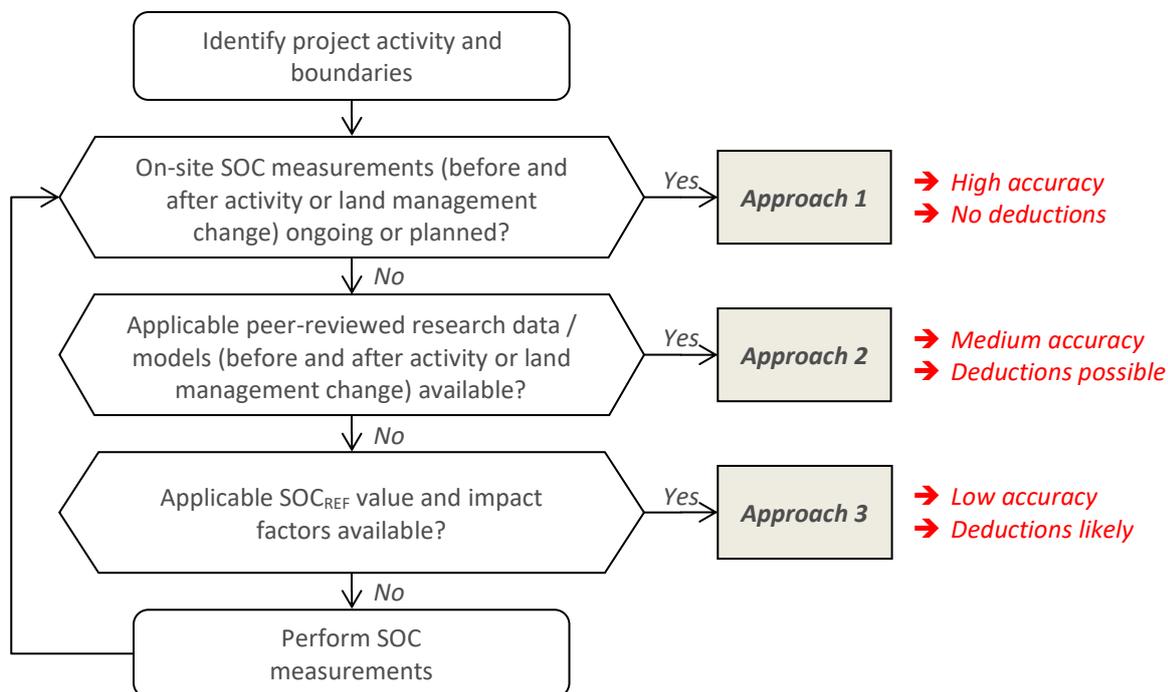
Figure 2: Decision tree for identification of appropriate calculation approach

6. Baseline Scenario

The relevant baseline scenario is the continuation of the historical land management practices that are being followed in last 5 years before the project start date (business as usual (BAU).

To determine the baseline of the eligible project area, the land shall be stratified into modelling units (MU) according to:

- Soil type
- Climate zone
- Land management / cropping system
- Input levels (e.g. fertilization)
- As applicable (to be defined in SOC Activity Modules):
  - Tillage practices
  - Soil properties (e.g. nutrient status or soil health)
  - Hydrology
  - Risk of carbon loss (e.g. fire risk)

For each stratum (MU), SOC measurements have to be performed (*Approach 1*) and/or model parameters identified and verified (*Approach 2 or 3*).

6.1 Baseline Calculations

For all of the eligible project area, baseline SOC stocks are calculated as the sum of stocks in each stratum multiplied by the stratum area as shown in **Equation 3**:

$$SOC_{BL} = \sum_{y=1}^{n}(SOC_{BL,y} \times A_y) \tag{3}$$

Where:

SOC_{BL} = *soil organic carbon in the eligible project area before project start [tC]*

$SOC_{BL,y}$ = *soil organic carbon in stratum y before project start [tC ha$_{-1}$]*

A_y = *area of stratum y before project start [ha]*

For each stratum in the eligible project area, baseline SOC stocks shall be quantified using any of the three general approaches. Different approaches may be used for different strata.

- **Approach *1*:** *$SOC_{BL,y}$* is measured in an adequate number of soil profiles to meet GS uncertainty requirements in each stratum (compare section 16.2). Measurement of SOC shall follow accepted sampling and analysis protocols (a list of approved protocols is provided in Appendix 1). As these protocols require a certain measure of field and laboratory technology, alternate protocols may be proposed in Activity Modules or at project level. Deviations from the protocols listed in the framework methodology or activity module (or use of alternate protocols) are subject to review and decision by The Gold Standard.

- **Approach *2*:** *$SOC_{BL,y}$* is derived from data or models published in peer-reviewed literature. Evidence for applicability of the literature values to the project site must be provided and validated as described in section 16.2. Specifically, applicability shall be demonstrated with respect to:
    - Climate factors (e.g. precipitation levels and seasonal distribution)
    - Soil and vegetation types
    - Current and historic management systems (land use category, crops, tillage techniques, fertilization)

Direct application of literature values is only permitted if the source conditions are comparable to the project environment, evidence of which shall be provided as described in section 16. Furthermore, literature values shall only be applied within the spatial and temporal dimensions analysed in the original source (e.g. SOC depth, timespan for which changes are documented). If a range of parameter values is given in a source or data is aggregated across various factor levels (e.g. average SOC in a region, across a range of soil types), the most conservative value shall be applied.

Alternatively, SOC values from literature may be verified by comparing them to measurements in a set of sample sites within the respective project stratum to indicate conservativeness of the parameter values applied. Such measurements are required if evidence for applicability (as listed above) of literature values is deemed insufficient by the Validation and Verification Body (VVB).

- **Approach 3:** If no data for $SOC_{BL,y}$ is available, it may be modelled using **Equation 4** (below). The calculation follows the approach documented in IPCC 2019[6] but allows for baseline management practices to be in place less than the estimated time to equilibrium (i.e., in case of IPCC default factors, less than 20 years). Note that the current IPCC Guidelines only provide stock change factors for tillage change and generic inputs (fertilizing) for croplands and grassland. Approach 3 is thus not applicable for activities increasing SOC in other manners (e.g. through biological soil agents) unless additional factors are available for the project area (e.g. Tier 2 factors from national GHG inventory).

$$SOC_{BL,y} = SOC_{REF,y} \times \left(1 + \left(F_{LU,y} \times F_{MG,BL,y} \times F_{I,BL,y} - 1\right) \times \frac{T_{BL}}{D_{BL}}\right) \qquad (4)$$

Where:

$SOC_{BL,y}$	= soil organic carbon before project start in stratum y [tCha-1]
$SOC_{REF,y}$	= reference soil organic carbon stock under natural vegetation in stratum y [tC ha-1]
$F_{LU,y}$	= land use factor in stratum y [dimensionless]
$F_{MG,BL,y}$	= tillage factor before project start in stratum y [dimensionless]
$F_{I,BL,y}$	= input factor before project start in stratum y [dimensionless]
D_{BL}	= time dependency of $F_{MG, BL}$ and $F_{I,BL}$ factors[7] [yr]
T_{BL}	= number of years since introduction of baseline practice; maximum $T_{BL} = D$ [yr]

In this approach, $SOC_{REF,y}$ shall be selected from an appropriate scientific source[8] or measurements, applicability of which in the project stratum shall be

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[6] 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 4 Agriculture, Forestry and Other Land Use (https://www.ipcc-nggip.iges.or.jp/public/2019rf/vol4.html)

[7] For IPCC 2019 and IPCC 2006 default factors, *D* equals 20 years

[8] Publications, verifiable local research results, soil databases e.g. ISRIC (https://www.isric.org/explore), Hengl et al., (2014), or the European Soil Portal (http://eusoils.jrc.ec.europa.eu/; also provides information on non-European soils). IPCC default SOC reference values (SOC_{REF}) may only be applied if within Gold Standard Uncertainty Requirements.

documented. This must include evidence that the SOC_{REF} value stems from a comparable climatic, soil and vegetation environment, as described in section 16. If evidence provided for applicability of SOC_{REF} is deemed insufficient by VVB, appropriate measurements are required.

For $F_{LU,BL,y}$, $F_{MG,BL,y}$ and $F_{I,BL,y}$ factors, default values from the IPCC 2019 guidelines may be applied within a given temperature and moisture regime (see Table 3 and Table 4 below), referring to the management before project start. If national or regional factors are available (IPCC Tier 2 or Tier 3 data) these should be used instead.

Table 3: Relative stock change factors (F_{LU}, F_{MG}, F_I) for grassland management (IPCC 2019)[9]

RELATIVE STOCK CHANGE FACTORS (F_{LU}, F_{MG}, AND F_I) FOR GRASSLAND MANAGEMENT					
Factor value type	**Level**	**Temperature regime**	**IPCC defaults**	**Error[1,2]**	**Description**
Land use (F_{LU})	All	All	1.0	N/A	All native and/or permanent grassland in a nominal condition is assigned a land-use factor of 1.
Management (F_{MG})	Nominally managed (non – degraded)	All	1.0	N/A	Represents low or medium intensity grazing regimes, in addition to periodic cutting and removal of above-ground vegetation, without significant management improvements.
Management (F_{MG})	High Intensity Grazing[3]	All	0.90	±8%	Represents high intensity grazing systems (or cutting and removal of vegetation) with shifts in vegetation composition and possibly productivity but is not severely degraded[4].
Management (F_{MG})	Severely degraded	All	0.7	±40%	Implies major long-term loss of productivity and vegetation cover, due to severe mechanical damage to the vegetation and/or severe soil erosion.

[9] IPCC 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4 Agriculture, Forestry and Other Land Use, Chapter 6 Grassland, table 6.2 (Updated). https://www.ipcc-nggip.iges.or.jp/public/2019rf/vol4.html

RELATIVE STOCK CHANGE FACTORS (F_{LU}, F_{MG}, AND F_I) FOR GRASSLAND MANAGEMENT					
Factor value type	**Level**	**Temperature regime**	**IPCC defaults**	**Error[1,2]**	**Description**
Management (F_{MG})	Improved grassland	Temperate/ Boreal	1.14	±11%	Represents grassland which is sustainably managed with light to moderate grazing pressure (or cutting and removal of vegetation) and that receive at least one improvement (e.g., fertilization, species improvement, irrigation).
		Tropical	1.17	±9%	
		Tropical Montane[5]	1.16	±40%	
Input (applied only to improved grassland) (F_I)	Medium	All	1.0	NA	Applies to improved grassland where no additional management inputs have been used.
Input (applied only to improved grassland) (F_I)	High	All	1.11	±7%	Applies to improved grassland where one or more additional management inputs/improvements have been used (beyond that required to be classified as improved grassland).

Management factors were derived using methods and studies provided in IPCC 2019, Annex 6A1. The basis for the other factors is described in the 2006 IPCC Guidelines.
Source:
[3] The bibliography for the following references used for management factor can be found in Annex 6A.1:
Cao *et al.*, 2013; Ding *et al.*, 2014; Du *et al.*, 2017; Frank *et al.*, 1995; Franzluebbers and Stuedemann, 2009; Gao *et al.*, 2018; Gao *et al.*, 2007; Gillard, 1969; Han *et al.*, 2008; He *et al.*, 2008; Ingram *et al.*, 2008; Kioko *et al.*, 2012; Kölbl *et al.*, 2011; Li *et al.*, 2008; Liu *et al.*, 2012; Manley *et al.*, 1995; Martinsen *et al.*, 2011; Potter *et al.*, 2001; Qi *et al.*, 2010; Rutherford and Powrie, 2011; Schulz *et al.*, 2016; Schuman *et al.*, 1999; Segoli *et al.*, 2015; Smoliak *et al.*, 1972; Sun *et al.*, 2011; Talore *et al.*, 2016; Teague *et al.*, 2011; Wang *et al.*, 2017; Wei *et al.*, 2011; Xu *et al.*, 2014; Yanfen *et al.*, 1998; Zhang *et al.*, 2018; Zhou *et al.*, 2010; Zou *et al.*, 2015
Notes:
[1] ± two standard deviations, expressed as a percent of the mean; where sufficient studies were not available for a statistical analysis a default, based on expert judgement, of + 40% is used as a measure of the error. NA denotes 'Not Applicable', for factor values that constitute reference values or nominal practices for the input or management classes.
[2] This error range does not include potential systematic error due to small sample sizes that may not be representative of the true impact for all regions of the world.
[4] High intensity grazing may be moderately degraded, but do not represent excessive grazing intensity that leads to severe grassland
[5] There were not enough studies to estimate stock change factors for mineral soils in the tropical montane climate region. As an approximation, the average stock change between the temperate and tropical regions was used to approximate the stock change for the tropical montane climate.

Table 4: Relative stock change factors (F_{LU}, F_{MG}, F_I) for different management activities on cropland (IPCC 2019[10])

RELATIVE STOCK CHANGE FACTORS (F_{LU}, F_{MG}, AND F_I) (OVER 20 YEARS) FOR DIFFERENT MANAGEMENT ACTIVITIES ON CROPLAND						
Factor value type	**Level**	**Temperature regime**	**Moisture regime[1]**	**IPCC defaults**	**Error[2,3]**	**Description**
Land use[5] (F_{LU})	Long-term cultivated	Cool Temperate / Boreal	Dry	0.77	±14%	Represents area that has been converted from native conditions and continuously managed for predominantly annual crops over 50 yrs. Land-use factor has been estimated under a baseline condition of full tillage and nominal ("medium") carbon input levels. Input and tillage factors are also applied to estimate carbon stock changes, which includes changes from full tillage and medium input.
			Moist	0.70	±12%	
		Warm Temperate	Dry	0.76	±12%	
			Moist	0.69	±16%	
		Tropical	Dry	0.92	±13%	
			Moist/ Wet	0.83	±11%	
Land use[6] (F_{LU})	Paddy rice	All	Dry and Moist/ Wet	1.35	±4%	Long-term (> 20 year) annual cropping of wetlands (paddy rice). Can include double-cropping with non-flooded crops. For paddy rice, tillage and input factors are not used.
Land use[5] (F_{LU})	Perennial/ Tree Crop	Temperate / Boreal	Dry and Moist	0.72	±22%	Long-term perennial tree crops such as fruit and nut trees, coffee and cacao.
		Tropical	Dry and Moist/ Wet	1.01	±25%	
Land use (F_{LU})	Set aside (< 20 yrs)	Temperate / Boreal and Tropical	Dry	0.93	±11%	Represents temporary set aside of annually cropland (e.g., conservation reserves) or other idle cropland that has been revegetated with perennial grasses.
			Moist/ Wet	0.82	±17%	
		Tropical montane[4]	n/a	0.88	±50%	
Tillage (F_{MG})	Full	All	Dry and Moist/ Wet	1.00	n/a	Substantial soil disturbance with full inversion and/or frequent (within year) tillage operations. At planting time, little (e.g., <30%) of the surface is covered by residues.
Tillage[7]	Reduced		Dry	0.98	±5%	

[10] IPCC 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4 Agriculture, Forestry and Other Land Use, Chapter 5 Cropland, table 5.5 (Updated). https://www.ipcc-nggip.iges.or.jp/public/2019rf/vol4.html

RELATIVE STOCK CHANGE FACTORS (F_{LU}, F_{MG}, AND F_I) (OVER 20 YEARS) FOR DIFFERENT MANAGEMENT ACTIVITIES ON CROPLAND						
Factor value type	Level	Temperature regime	Moisture regime[1]	IPCC defaults	Error[2,3]	Description
(F_{MG})		Cool Temperate / Boreal	Moist	1.04	±4%	Primary and/or secondary tillage but with reduced soil disturbance (usually shallow and without full soil inversion). Normally leaves surface with >30% coverage by residues at planting.
		Warm Temperate	Dry	0.99	±3%	
			Moist	1.05	±4%	
		Tropical	Dry	0.99	±7%	
			Moist/ Wet	1.04	±7%	
		n/a	n/a	n/a	n/a	
Input (F_I)	Low	Temperate / Boreal	Dry	0.95	±13%	Low residue return occurs when there is removal of residues (via collection or burning), frequent bare-fallowing, production of crops yielding low residues (e.g., vegetables, tobacco, cotton), no mineral fertilization or N-fixing crops.
			Moist	0.92	±14%	
		Tropical	Dry	0.95	±13%	
			Moist/ Wet	0.92	±14%	
		Tropical montane[4]	n/a	0.94	±50%	
Input (F_I)	Medium	All	Dry and Moist/ Wet	1.00	n/a	Representative for annual cropping with cereals where all crop residues are returned to the field. If residues are removed then supplemental organic matter (e.g., manure) is added. Also requires mineral fertilization or N-fixing crop in rotation.
Input (F_I)	High - without manure	Temperate / Boreal and Tropical	Dry	1.04	±13%	Represents significantly greater crop residue inputs over medium C input cropping systems due to additional practices, such as production of high residue yielding crops, use of green manures, cover crops, improved vegetated fallows, irrigation, frequent use of perennial grasses in annual crop rotations, but without manure applied (see row below).
			Moist/ Wet	1.11	±10%	
		Tropical montane[4]	n/a	1.08	±50%	
Input (F_I)	High - with manure	Temperate / Boreal and Tropical	Dry	1.37	±12%	Represents significantly higher C input over medium C input cropping systems due to an additional practice of regular addition of animal manure.
			Moist/ Wet	1.44	±13%	
		Tropical montane[4]	n/a	1.41	±50%	

Factor value type	Level	Temperature regime	Moisture regime[1]	IPCC defaults	Error[2,3]	Description

Notes: Long-term cultivation, perennial crops paddy rice and tillage management factors were derived using methods provided in IPCC 2019, Annex 5A1.

[1] Where data were sufficient, separate values were determined for temperate and tropical temperature regimes; and dry, moist, and wet moisture regimes. Temperate and tropical zones correspond to those defined in Chapter 3; wet moisture regime corresponds to the combined moist and wet zones in the tropics and moist zone in temperate regions.

[2] ± two standard deviations, expressed as a percent of the mean; where sufficient studies were not available for a statistical analysis to derive a default, uncertainty was assumed to be + 50% based on expert opinion. NA denotes 'Not Applicable', where factor values constitute defined reference values, and the uncertainties are reflected in the reference C stocks and stock change factors for land use.

[3] This error range does not include potential systematic error due to small sample sizes that may not be representative of the true impact for all regions of the world.

[4] There were not enough studies to estimate some of the stock change factors for mineral soils in the tropical montane climate region. As an approximation, the average stock change between the temperate and tropical regions was used to approximate the stock change for the tropical montane climate.

7. Project Scenario

Under the project scenario, SOC relevant practices are applied in the project area. As with the baseline, the eligible project area shall be stratified into modelling units (MU) according to:

- Soil type
- Climate zone
- Land management / cropping system
- Input levels (e.g. fertilization)
- As applicable (to be defined in SOC Activity Modules):
  - Tillage practices
  - Soil properties (e.g. nutrient status or soil health)
  - Hydrology
  - Risk of carbon loss (e.g. fire risk)

For each stratum (MU), SOC measurements have to be performed (*Approach 1*) and/or model parameters identified and verified (*Approach 2 or 3*).

7.1 Project Scenario Calculations

For all of the eligible project area, SOC stocks at time *t* are calculated as the sum of stocks in each stratum multiplied by the stratum area:

$$SOC_t = \sum_{y=1}^{n}(SOC_{t,y} \times A_y) \hspace{2cm} (5)$$

Where:

SOC_t = *soil organic carbon in the eligible project area at time t [tC]*

$SOC_{t,y}$ = *soil organic carbon in stratum y at time t [tC ha-1]*

A_y = *area of stratum y at time t [ha]*

For each stratum in the eligible project area, SOC stocks are quantified using any of the three approaches. If a different approach is used for baseline and project scenarios in a stratum, conservativeness and comparability have to be ensured, following the procedures outlined in section 8 below and model assessment criteria in section 16.2.

- **Approach *1*:** $SOC_{t,y}$ is measured in an adequate number of soil profiles to meet Gold Standard uncertainty requirements in each stratum (compare section 16.2). Currently accepted protocols are the ICRAF protocol[11] and the VCS SOC Module[12]. As these protocols require a certain measure of field and laboratory technology, alternate protocols may be proposed in SOC Activity Modules or on project level. Deviations from the protocols listed in the framework methodology or activity module (or use of alternate protocols) are subject to review and decision by The Gold Standard.

For ex-ante calculations, literature references or an accepted soil carbon model shall be used, following Approach 2 below.

- **Approach *2*:** $SOC_{t,y}$ is derived from data published in peer-reviewed literature or accepted soil carbon models[13]. Evidence for applicability of the literature values and model parameters to the project site must be provided and validated as described in section 16.2. Specifically, applicability shall be shown with respect to:
    - Climate factors (e.g. precipitation levels and seasonal distribution)
    - Soil and vegetation types
    - Current and historic management systems (land use category, crops, tillage techniques, fertilization)

  Direct application of literature values is only permitted if the source conditions are comparable to the project environment, evidence of which shall be provided as described in section 16. Furthermore, literature values shall only be applied within the spatial and temporal dimensions analysed in the original source (e.g. SOC depth, timespan for which

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[11] Aynekulu, E. Vagen, T-G., Shephard, K., Winowiecki, L. 2011. A protocol for modeling, measurement and monitoring soil carbon stocks in agricultural landscapes. Version 1.1. World Agroforestry Centre (ICRAF), Nairobi. (http://old.worldagroforestry.org/downloads/Publications/PDFS/TM11192.pdf)

[12] Verified Carbon Standard (VCS) 2012. Module VMD0021 Estimation of Stock in The Soil Carbon Pool (Version 1.0). (https://verra.org/methodology/vmd0021-estimation-of-stocks-in-the-soil-carbon-pool-v1-0/)

[13] such as RothC (https://www.rothamsted.ac.uk/rothamsted-carbon-model-rothc) or Century (http://www.nrel.colostate.edu/projects/century/) soil carbon models

changes are documented). If a range of parameter values is given in a source or data is aggregated across various factor levels (e.g. average SOC in a region, across a range of soil types), the most conservative value shall be applied.

Alternatively, the SOC values from literature may be verified by comparing them to measurements in a set of sample sites within the respective project stratum to indicate conservativeness of the parameter values applied. Such measurements are required if evidence for applicability (as listed above) of literature values or model parameters is deemed insufficient by the VVB.

- **Approach 3:** If no data for $SOC_{t,y}$ is available, it may be modelled using the approach documented in IPCC 2019. The land use factors F_{LU}, F_{MG} and F_I used in this approach have a time dependency based on the estimated time to reach an equilibrium state after a management change (for IPCC 2019 and IPCC 2006 defaults factors, this is 20 years). **Equation 6** (below) provides an approach to account for shorter crediting periods and shall thus be applied.

$$SOC_{t,y} = SOC_{BL,y} + \Delta SOC_{t,y}$$
$$\Delta SOC_{t,y} = SOC_{REF,y} \times F_{LU,y} \times \left(F_{MG,PR,y} \times F_{I,PR,y} - F_{MG,BL,y} \times F_{I,BL,y}\right) \times \frac{T_{PR}}{D_{PR}} \quad (6)$$

Where:

$SOC_{t,y}$ = soil organic carbon in stratum y at time t [tC ha^{-1}]

$SOC_{BL,y}$ = soil organic carbon in stratum y before project start (see equation 9) [tC ha^{-1}]

$\Delta SOC_{t,y}$ = change in soil organic carbon since project start in stratum y at time t [tC ha^{-1}]

$SOC_{REF,y}$ = reference soil organic carbon stock under natural vegetation in stratum y [tC ha^{-1}]

$F_{LU,y}$ = land use factor in stratum y [dimensionless]

$F_{MG,BL,y}$ = tillage factor before project start in stratum y [dimensionless]

$F_{I,BL,y}$ = input factor before project start in stratum y [dimensionless]

$F_{MG,PR,y}$ = tillage factor under the project scenario in stratum y [dimensionless]

$F_{I,PR,y}$ = input factor under the project scenario in stratum y [dimensionless]

D_{PR} = time dependency of $F_{MG,PR}$ and $F_{I,PR}$ factors[14] [yr]

14 For IPCC 2019 and IPCC 2006 default factors, *D* equals 20 years

T_{PR} = *number of years since project start at time t; maximum T_{PR} = D [yr]*

Under the applicability conditions of this Framework Methodology, no land use change is taking place and thus the $SOC_{REF,y}$ and $FL_{U,y}$ values are identical to the respective baseline values.

For $FM_{G,PR,y}$ and $F_{I,PR,y}$ factors, default values from the IPCC 2019 guidelines may be applied within a given temperature and moisture regime as in the baseline scenario (see Table 3 and Table 4), but now referring to the management and input levels under the project scenario. Note that the same climate zone and soil type as for baseline calculations shall be used. If national or regional factors are available (IPCC Tier 2 or Tier 3 data) these should be used instead. In such cases, time dependency D also has to be matched to the respective source.

8. Procedures for Approach Change

Any approach change between baseline and project scenario calculations shall meet the following conditions and procedures:

1. If approach 1 or 2 are used for quantification, change to approach 3 is not allowed.
2. At project start, calculations result from both approaches shall be compared. Differences shall be assessed and procedures below applied:
   a. Neutral change: If SOC stocks calculated (Approach 2) or measured (Approach 1) at project start do not differ by more than 5% of the stocks calculated and verified with the previous approach for the baseline scenario (see section 16.2), the transition can be considered neutral and may be permitted. The result of the new Approach shall be applied for stock change calculations. Exception: If the baseline stock was measured under Approach 1 and this baseline SOC value is higher than the new Approach 2 result, the measured baseline value shall remain to ensure conservativeness.

   b. SOC change (modelled): If SOC stocks calculated with a new Approach 2 method differ by more than 5% from the stocks calculated and verified with the previous approach for the baseline scenario, the applicability of the selected dataset or model and parametrization shall be reviewed at project validation. If the model and data is deemed applicable upon review by the VVB, the baseline value shall be corrected accordingly. Exception: If the baseline stock was measured under Approach 1 and this baseline SOC value is higher than the new Approach 2 result, the measured baseline value shall remain to ensure conservativeness.

c. SOC change (measured): If SOC stocks measured with a new Approach 1 sample differ by more than 5% from the stocks calculated and verified with the previous approach for the baseline scenario, the baseline value shall be corrected accordingly.

Table 5 illustrative examples for approach change, change assessment and outcome.

Table 5: Examples for Approach Changes

Baseline scenario approach		Project scenario approach		Change assessment			Change outcome	
Approach	SOC Stock	Approach	SOC Stock	Change rationale	Change rule	Review result (if applicable)	Baseline value	Approach for project scenario
Appr. 3	55 ± 8%	Appr. 2	54 ± 4%	The project owner applies a specific SOC model for the practices under project scenario. This model is not applicable under the baseline scenario due to lack of historic data. A simpler model is used for the baseline calculations.	Rule 2a): Difference is less than 5% → change is neutral	n/a	54	Appr. 2
Appr. 3	143 ± 30%[15]	Appr. 2	126 ± 6%		Rule 2b): Difference is more than 5% → Review needed	Model confirmed	126	Appr. 2
Appr. 2	37 ± 12%	Appr. 2	39 ± 5%		Rule 2a): Difference is less than 5% → change is neutral	n/a	39	Appr. 2 (new model)
Appr. 1	45 ± 2%	Appr. 2	47 ± 8%	Data collected in the baseline period has been expanded with regional soil data and a regional SOC model has been created ad published. The project owner wants to use the high-accuracy measured baseline data but use a model approach going forward.	Rule 2a): Difference is less than 5% → change is neutral	n/a	47	Appr. 2
Appr. 1	68 ± 2%	Appr. 2	65 ± 8%		Rule 2a): Difference is less than 5% → special case: higher measured value to be kept as baseline	n/a	68	Appr. 2
Appr. 1	93 ± 4%	Appr. 3	93 ± 4%	Previous SOC measurement is discontinued at project start. The project owner wants to apply the (measured) start value in an Approach 3 model.	Rule 1): Not allowed	n/a	To be revised	To be revised
Appr. 3	82 ± 14%	Appr. 1	69 ± 9%	The project owner intends to perform measurements in the project area throughout the crediting period. However, such measurements are not available for the baseline period. Instead, a simple Approach 3 model was used for baseline calculations.	Rule 2c): Measurements take precedence (even if difference is >5%)	n/a	69	Appr. 1

[15] Applying a parameter with a high uncertainty will likely result in an uncertainty deduction off the benefits (see Section 9). In the assessment of the approach change, this does not have an impact.

9. Uncertainty

The project proponent shall use a precision of 20% of the mean at the 90% confidence level as the criteria for accuracy of total SOC change calculation. This target precision shall be achieved by selecting appropriate models, parameters, sampling and measurement techniques in accordance with *Annex A - Uncertainty of LUF Parameters*, LUF Activity Requirements for the three approaches under this Framework Methodology.

Overall uncertainty for calculation of emissions reduction is performed as follows[16]:

Step 1: Calculate upper and lower confidence limits for all input parameters

Calculate the mean $\bar{X}_p$, and standard deviation σ_p, for each parameter and coefficient used in emissions calculations. The standard error of the mean is then given by

$$SE_p = \frac{\sigma_p}{\sqrt{n_p}} \tag{7}$$

Where:

    SE_p   = *Standard error in the mean of parameter p*

    σ_p   = *Standard deviation of the parameter p*

    n_p   = *Number of samples used to calculate the mean and standard deviation of parameter p*

If SE_p (mean standard error) is available directly from the parameter source (e.g. literature, metadata) it may be used directly in the following calculations (without the use of Equation 7).

Assuming that values of the parameter are normally distributed about the mean, values for the upper and lower confidence intervals for the parameters are given by

$$Lower_p = \bar{X}_p - t_{np} \times SE_p \tag{8}$$

$$Upper_p = \bar{X}_p + t_{np} \times SE_p$$

Where:

    $Lower_p$ = *Value at the lower end of the 90% confidence interval for parameter p*

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[16] This chapter on uncertainty is adapted from VCS VM0017 and approved registered "Gold Standard Agriculture Methodology for Increasing Soil Carbon Through Improved Tillage Practices".

Upper_p = Value at the upper end of the 90% confidence interval for parameter p

$\bar{X}_p$ = Mean value for parameter p

SE_p = Standard error in the mean of parameter p

t_np = t-value for the cumulative normal distribution at 90% confidence interval for the number of samples n_p for parameter p (apply Table 6 below). If no information is available on n_p a conservative value of 1.675 (n=3) shall be used.

Table 6: t-values (t_{np}) applicable in equation (8). Select appropriate t_{np} value depending on the number of samples (n_p) measured for parameter *p*.

n_p	t_{np}	n_p	t_{np}	n_p	t_{np}	n_p	t_{np}	n_p	t_{np}	n_p	t_{np}	n_p	t_{np}
		31	1.6973	61	1.6706	91	1.6620	121	1.6577	151	1.6551	181	1.6534
		32	1.6955	62	1.6702	92	1.6618	122	1.6575	152	1.6550	182	1.6533
3	2.9200	33	1.6939	63	1.6698	93	1.6616	123	1.6574	153	1.6549	183	1.6533
4	2.3534	34	1.6924	64	1.6694	94	1.6614	124	1.6573	154	1.6549	184	1.6532
5	2.1319	35	1.6909	65	1.6690	95	1.6612	125	1.6572	155	1.6548	185	1.6532
6	2.0150	36	1.6896	66	1.6686	96	1.6610	126	1.6571	156	1.6547	186	1.6531
7	1.9432	37	1.6883	67	1.6683	97	1.6609	127	1.6570	157	1.6547	187	1.6531
8	1.8946	38	1.6871	68	1.6679	98	1.6607	128	1.6570	158	1.6546	188	1.6531
9	1.8595	39	1.6859	69	1.6676	99	1.6606	129	1.6568	159	1.6546	189	1.6530
10	1.8331	40	1.6849	70	1.6673	100	1.6604	130	1.6568	160	1.6545	190	1.6529
11	1.8124	41	1.6839	71	1.6669	101	1.6602	131	1.6567	161	1.6544	191	1.6529
12	1.7959	42	1.6829	72	1.6666	102	1.6601	132	1.6566	162	1.6544	192	1.6529
13	1.7823	43	1.6820	73	1.6663	103	1.6599	133	1.6565	163	1.6543	193	1.6528
14	1.7709	44	1.6811	74	1.6660	104	1.6598	134	1.6564	164	1.6543	194	1.6528
15	1.7613	45	1.6802	75	1.6657	105	1.6596	135	1.6563	165	1.6542	195	1.6528
16	1.7530	46	1.6794	76	1.6654	106	1.6595	136	1.6562	166	1.6542	196	1.6527
17	1.7459	47	1.6787	77	1.6652	107	1.6593	137	1.6561	167	1.6541	197	1.6527
18	1.7396	48	1.6779	78	1.6649	108	1.6592	138	1.6561	168	1.6540	198	1.6526
19	1.7341	49	1.6772	79	1.6646	109	1.6591	139	1.6560	169	1.6540	199	1.6526
20	1.7291	50	1.6766	80	1.6644	110	1.6589	140	1.6559	170	1.6539	≥200	1.6525
21	1.7247	51	1.6759	81	1.6641	111	1.6588	141	1.6558	171	1.6539		
22	1.7207	52	1.6753	82	1.6639	112	1.6587	142	1.6557	172	1.6538		
23	1.7172	53	1.6747	83	1.6636	113	1.6586	143	1.6557	173	1.6537		
24	1.7139	54	1.6741	84	1.6634	114	1.6585	144	1.6556	174	1.6537		
25	1.7109	55	1.6736	85	1.6632	115	1.6583	145	1.6555	175	1.6537		
26	1.7081	56	1.6730	86	1.6630	116	1.6582	146	1.6554	176	1.6536		
27	1.7056	57	1.6725	87	1.6628	117	1.6581	147	1.6554	177	1.6536		
28	1.7033	58	1.6720	88	1.6626	118	1.6580	148	1.6553	178	1.6535		
29	1.7011	59	1.6715	89	1.6623	119	1.6579	149	1.6552	179	1.6535		
30	1.6991	60	1.6711	90	1.6622	120	1.6578	150	1.6551	180	1.6534		

Step 2: Calculate SOC change (ΔCSOC,t-0) with the lower and upper confidence interval values of the input parameters

Apply the *Lower* and *Upper* parameter values in the models for *ΔC_SOC,t-0* , i.e. equations for *SOC_BL* and *SOC_t*, to achieve a lower and upper value for *ΔC_SOC*

$$\text{Lower}_{\Delta\text{CSOC}} = \text{Model}_{\text{SOC}}\{\text{Lower}_p\}$$

(9)

$$\text{Upper}_{\Delta\text{CSOC}} = \text{Model}_{\text{SOC}}\{\text{Upper}_p\}$$

Where:

Lower_ΔCSOC = lower value of SOC change at a 90% confidence interval

Upper_ΔCSOC = upper value of SOC change at a 90% confidence interval

$Model_{SOC}$ = calculation models for SOC_t, SOC_0, SOC_{BL}

$Lower_p$ = values at the lower end of the 90% confidence interval for all parameters p

$Upper_p$ = values at the upper end of the 90% confidence interval for all parameters p

Step 3: Calculate the uncertainty in the model output

The uncertainty in the output model is given by

$$UNC = \frac{|Upper_{\Delta CSOC} - Lower_{\Delta CSOC}|}{2 \times \Delta C_{SOC}} \qquad (10)$$

Where:

UNC = model output uncertainty [%]

$Lower_{\Delta CSOC}$ = lower value of SOC change at a 90% confidence interval [tC]

$Upper_{\Delta CSOC}$ = upper value of SOC change at a 90% confidence interval [tC]

ΔC_{SOC} = change in soil organic carbon stocks [tC]

Step 4: Adjust the estimate of SOC change ($\Delta CSOC,t-0$) based on the uncertainty in the model output

If the uncertainty of SOC change models is less than or equal to 20% of the mean SOC change value then the project owner may use the estimated value without any deduction for uncertainty, i.e. $UD = 0$ in Equation 2.

If the uncertainty of soil models is greater than 20% of the mean value, then the project owner shall use the estimated value subject to an uncertainty deduction (UD) in Equation 2, calculated as

$$UD = UNC - 20\% \qquad (11)$$

Where:

UD = uncertainty deduction [%]

UNC = model output uncertainty (>20%) [%]

10. Other Emissions

Significant additional greenhouse gas emissions (>5% total) due to the project activity need to be accounted for. This explicitly includes emissions from increased fertilizer input and fossil fuel combustion. Activity Modules may define additional other emissions required.

$$PE_{t-0} = \Delta FE_{t-0} + \Delta FU_{t-0} + \Delta AE_{t-0} \qquad (12)$$

Where:

PE_{t-0} = emissions from project activities in the calculation period [tCO$_2$e]

ΔFE_{t-0} = emissions from increased fertilizer use in the calculation period [tCO2e]

ΔFU_{t-0} = emissions from increased fuel and electricity use in the calculation period [tCO2e]

ΔAE_{t-0} = other agrochemical emissions in the calculation period [tCO2e]

10.1 Increased Nitrogen Fertilizer Input

Emissions from increased nitrogen (N) fertilizer input in project scenario as compared to the baseline scenario are calculated as follows. No differentiation is made between synthetic and organic N fertilizer. Note that this formula is not applicable for decreases in N fertilizer input, in which case $\Delta FE_{t-0,y}$ is considered 0. To account for reductions in fertilizer input (and the respective GHG emissions reductions), a separate Gold Standard methodology may be applied.

$$\Delta FE_{t-0} = EF_{FE} \times \sum_{a=1}^{T}(FE_{PR,a} - FE_{BL}) \tag{13}$$

Where:

ΔFE_{t-0} = emissions from increased fertilizer use in the calculation period [tCO2e]. Must be ≥ 0 in this methodology (i.e. no accounting of reductions).

$FE_{PR,a}$ = N fertilizer input under the project scenario in year a of the calculation period [kgN]

FE_{BL} = mean annual N fertilizer input under the baseline scenario [kgN]

T = number of years in the calculation period [yr]

EF_{FE} = Conversion factor for emissions from N fertilizer [tCO2e kgN-1]. IPCC 2019 aggregated default value[17] for EF_{FE} is 0.01. Disaggregated default values in IPCC 2019 Table 11.1 may be used if fertilizer inputs are known per fertilizer type.

FE_{PR} and FE_{BL} shall be documented by the project owner. For FE_{BL}, mean annual input is calculated based on respective management records for 5 years prior to project start. If no adequate documentation can be provided, FE_{BL} shall be no more than 50% of FE_{PR}.

10.2 Increased Combustion of Fossil Fuels and Electricity Use

Additional CO_2 emissions from use of fossil fuel and electricity in project activities (e.g. fuel used by farm machines due to needs for stronger tractors or additional passes to close/treat the surface, or fuel/electricity for irrigation pumps) need to be accounted for, unless project owner can demonstrate that fossil fuel/electricity used in the project scenario is less than or does not differ significantly from fossil fuel/electricity used in the baseline, in which case ΔFU_{t-0} is considered 0.

$$\Delta FU_{t-0} = \sum_{a=1}^{T}(FU_{PR,a} - FU_{BL}) + (EU_{PR,a} - EU_{BL}) \tag{14}$$

Where:

17 IPCC 2019, Vol 4 AFOLU, Table 11.1 (Aggregated default value)

ΔFU_{t-0} = emissions from increased fossil fuel and electricity use in the calculation period [tCO₂e]

FU_{PR,a} = emissions from use of fossil fuels under the project scenario in year a of the calculation period [tCO₂e]

FU_{BL} = mean annual emissions from use of fossil fuels under the baseline scenario [tCO₂e]

EU_{PR,a} = emissions from use of electricity under the project scenario in year a of the calculation period [tCO₂e]

EU_{BL} = mean annual emissions from use of electricity under the baseline scenario [tCO₂e]

T = number of years in the calculation period [yr]

FU_{PR} and FU_{BL} shall be documented by the project owner and generally calculated with the equation below, based on fuel consumption by machine type and fuel emission factor.

$$FU_{i,a} = \sum_{MT} FUL_{i,MT,a} \times FEF_{i,MT} \tag{15}$$

Where:

$FU_{i,a}$ = emissions from use of fossil fuels in year a [tCO₂e ha⁻¹]

$FUL_{i,MT,a}$ = fuel consumption by the machinery type MT used in year a [litres]

$FEF_{i,MT}$ = emissions factor for the fuel used in machinery MT [tCO₂e litres⁻¹]

MT = machinery type (gasoline two-stroke, gasoline four-stroke, diesel)

i = formula used for baseline (i=BL) as well as project scenario (i=PR)

For FU_{BL}, mean annual emissions are calculated based on respective management records for 5 years prior to project start. If this is not available, the amount of fuel combusted can be estimated using fuel efficiency (for example l/100 km, l/t-km, l/hour) of the vehicle and the appropriate unit of use for the selected fuel efficiency (for example km driven if efficiency is given in l/100 km). If no adequate documentation can be provided, FU_{BL} shall be no more than 50% of FU_{PR}.

Non-CO_2 GHG emissions caused by the use of fossil fuel from project activities (management operations, machinery, etc.) are insignificant and may thus be neglected.

EU_{PR} and EU_{BL} shall be documented by the project owner and generally calculated with the equation below, based on electricity consumption by appliance and respective emission factor. If electricity is generated on-site using fossil fuels (e.g. in diesel generators for irrigation pumps), emissions from fuel combustion should be calculated instead, following the approach described above.

$$EU_{i,a} = \sum_{SE} EUW_{i,SE,a} \times EEF_{i,SE} \tag{16}$$

Where:

$EU_{i,a}$ = emissions from use of fossil fuels in year a [tCO$_2$e ha$_{-1}$]

$EUW_{i,SE,a}$ = electricity consumption from source SE in year a [kWh]

$EEF_{i,SE}$ = emissions factor for the electricity used in source SE [tCO$_2$e kWh$_{-1}$]

SE = electricity source type (grid, fossil fuel generator, etc)

i = formula used for baseline (i=BL) as well as project scenario (i=PR)

For EU_{BL}, mean annual emissions are calculated based on respective management records for 5 years prior to project start. If no adequate documentation can be provided, EU_{BL} shall be no more than 50% of EU_{PR}.

10.3 Other Agrochemical Emissions

Additional agrochemical emissions (*AE*) related to the project activities from increased use of agrochemicals, especially pesticides or non-N fertilizers need to be accounted for, unless the project owner can demonstrate that agrochemicals used in the project scenario are less than or do not differ significantly from agrochemicals used in the baseline, in which case ΔAE_{t-0} is considered 0.

If use of agrochemicals (herbicides, pesticides) or non-N fertilizer is significantly higher in the project than in the baseline scenario, the project owner shall calculate respective emissions by using specific amounts and emission factors. Emission factors applied shall be based on manufacturer information or scientific sources.

$$\Delta AE_{t-0} = \sum_{a=1}^{T}\left(AE_{PR,a} - AE_{BL}\right) \tag{17}$$

Where:

ΔAE_{t-0} = additional emissions from project activity in the calculation period [tCO$_2$e]

$AE_{PR,a}$ = other emissions under the project scenario in year a of the calculation period [tCO$_2$e]

AE_{BL} = other emissions (annual mean) under the baseline scenario [tCO$_2$e]

T = number of years in the calculation period [yr]

AE_{PR} and AE_{BL} shall be documented for each emitter type (agrochemical) by the project owner and calculated with the equation below, based on emission type, underlying quantity and respective emission factor.

$$AE_{i,a} = \sum_{ET} AQ_{i,ET,a} \times AEF_{i,ET} \tag{18}$$

Where:

$AE_{i,a}$ = emissions from use of other agrochemicals in year a [tCO2e ha$_{-1}$]

$AQ_{i,ET,a}$ = quantity of agrochemicals for emitter type ET applied in year a [kg]

$AEF_{i, ET}$ = emissions factor of the agrochemical used (for emitter type ET) [tCO2e kg$_{-1}$]

ET = emitter type (specific pesticide, fertilizer, or other agrochemical)

i = formula used for baseline (i=BL) as well as project scenario (i=PR)

For AE_{BL}, mean annual emissions are calculated based on respective management records for 5 years prior to project start. If no adequate documentation can be provided, AE_{BL} shall be no more than 50% of AE_{PR}.

11. Leakage

Leakage is defined as an increase in GHG emissions outside the project area as a result of project activities. Activity Modules shall provide leakage calculations if applicable.

In the context of this Framework Methodology and respective Activity Modules, leakage could occur inter alia in relation to shift of crop production to other lands to compensate for yield reductions or to emissions from increased C runoff.

Under this Framework Methodology's applicability conditions, projects are not allowed on wetlands, where C runoff could be an issue. Leakage from C runoff is thus considered 0.

And, concerning yield-related leakage, project sites are normally actively maintained for commodity production during the project crediting period and thus yield-related leakage risks are relatively small. Crop producers are commonly risk averse and are unlikely to intentionally suffer reduced crop yields. Moreover, under this Framework Methodology's applicability conditions and the LUF Activity Requirements, projects shall not lead to a decrease in agricultural productivity, thus all projects shall be set up to maintain or increase yield. Accordingly, this Framework Methodology's applicability conditions do not allow yield reduction.

For initial project calculations, LK_{t-0} is thus considered equal 0.

Nevertheless, if a reduction in yield is detected in a performance certification, it is assumed that the lost production capacity will have to be made up for on land outside the project area. Emissions caused by such a shift must be accounted for as leakage, unless the project owner provides evidence that yield reductions are caused by factors unrelated to the project activity, e.g. regional yield reduction due to weather.

Equation 19 is applied to calculate the carbon losses resulting from a reduction in crop yield (CY) and activity shift to a non-project land (leakage area) in a specific calculation period. In order to avoid undue accounting for leakage after temporary yield increases (i.e. no additional losses compared to the baseline

yield), reduction in crop yield is always calculated against the lowest yield in the project area since project start. Note that under these conditions, leakage shall only be calculated with Equation 19 if yield CY_t is lower than the minimal yield CYmin. Accounting of positive leakage is not allowed.

$$LK_{t-0} = \frac{CY_{min} - CY_t}{CY_{BL}} \times A \times (\Delta BC_{LA} + \Delta SOC_{LA,t-0} + \Delta FE_{LA,t-0} + \Delta FU_{LA,t-0}) \qquad (19)$$

Where:

LK_{t-0}	= emissions due to shift of production to non-project lands (leakage area) [tCO2e]
CY_t	= crop yield in the project area at time t (5-year average) [kg ha-1]
CY_{min}	= lowest crop yield in the project area in any calculation period since project start (5-year average) [kg ha-1]
CY_{BL}	= crop yield in the project area under the baseline scenario (5-year average) [kg ha-1]
A	= total eligible project area [ha]
ΔBC_{LA}	= change in biomass carbon stocks in leakage area [tCO2e ha-1]
$\Delta SOC_{LA,t-0}$	= change in soil organic carbon stocks in leakage area [tCO2e ha-1]
$\Delta FE_{LA,t-0}$	= change in emissions from use of fertilizer in leakage area [tCO2e ha-1]
$\Delta FU_{LA,t-0}$	= change in emissions from fuel use in leakage area [tCO2e ha-1]

CY_t, CY_{min} and CY_{BL} are based on project owner's documentation. For each point in time, the previous five years' average is used as yield quantity. Note that for the first calculation period CYmin equals CYBL.

ΔBC_{LA}, ΔSOC_{LA}, ΔFE_{LA}, ΔFU_{LA} are calculated as the difference between respective carbon stocks on the land to which the activity would most likely be shifted (i.e. the pre-shift vegetation cover and land use) and the long-term biomass carbon stock under the baseline cropping system.

For ΔBC_{LA} biomass carbon stocks according to IPCC (2019)[18] or applicable local literature values are compared to the respective stocks under the baseline cropping system. All other parameters are calculated according to the approaches described in this methodology, taking into account the situation in the leakage area (i.e. use of appropriate parameters for different soils or management practices).

12.   Double Counting and Benefits Overlap

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[18] IPCC 2019, Vol 4 AFOLU, table 4.7 (forests), table 4.8 (plantations), chapter 5.2.1 (cropland), chapter 6.2.1 (grassland).

Refer to the GHG Emissions Reductions & Sequestration Product Requirements Annex A "Double Counting Requirements" for cross-market or cross-project double counting rules. In addition, this section outlines rules to avoid double counting of benefits within a project (benefits overlap), e.g. due to implementation of multiple SOC activities applying multiple SOC Activity Modules.

Benefits overlap from SOC increase from multiple SOC activities would occur when impacts of activities are not cumulative yet calculated through independent approaches (e.g. with separate models or even separate approaches under the SOC Framework Methodology). To avoid such effects, the following rules shall be followed when applying multiple Activity Modules in one project under the Framework Methodology:

12.1 Project applying direct measurement (Approach 1 under the Framework Methodology) in at least one activity module applied

For strata with measured SOC impacts, the resulting difference represents impacts of all project activities, i.e. no additional model calculations for SOC increase shall be done.

For strata without measurements (i.e. where only SOC Activity Modules without direct measurement are applied), rules in section 12.2 (below) apply.

12.2 Projects applying SOC models or reference data (Approach 2 or 3 under the Framework Methodology) without direct measurements

If SOC pools impacted can be clearly separated between activities, either through chemical or physical differentiation in the soil (i.e. different soil organic components impacted) or due to geographical separation (i.e. impact in different strata), separate models or approaches may be applied to calculate cumulative impact.

If SOC pools impacted cannot be separated and cumulative impact cannot be proven (e.g. from published research comparing impacts in a combined study including interactions between activities), only benefits from one activity shall be accounted for. It is recommended that a direct measurement approach is implemented in such cases to provide evidence of cumulated impact.

13. Project Buffer

According to GHG Emissions Reduction & Sequestration Product Requirements, a fixed percentage of the validated and verified GS VERs must be transferred into the Gold Standard Compliance Buffer if the SOC activity results in sequestration (buffer is not required for emission reduction activities). The buffer is non-refundable, though the project owner may transfer GS VERs from other Gold

Standard certified projects to the Gold Standard Compliance Buffer in lieu of the GS VERs from the project.

14. Additionality

All GS projects shall demonstrate that they would not have been implemented without the benefits of carbon certification. Specific rules and guidelines on how to assess additionality can be found in the Additionality section LUF Activity Requirements and the AGR Additionality (AGR projects) Template.

15. Sustainable Development Goals

Primary SDG targeted by this Framework Methodology is SDG 13, through avoidance of emissions as well as sequestration of carbon in the soil. Contribution to further specific Sustainable Development Goals (SDGs) is not defined here as it is specified at the project level following Principles & Requirements.

16. Monitoring

16.1 Monitoring frequency and performance reviews

The project proponent shall submit a monitoring report at each verification and performance review according to Principles & Requirements.

In addition, the project proponent shall submit an annual report containing at least the information listed in Principles & Requirements using the Annual Report Template, and those labelled as annually in below monitoring tables.

The project proponent shall also collect and document evidence that the methodology's applicability conditions are met at all times. The project proponent shall:

- Electronically archive all monitoring data collected in the last crediting period for up to 2 years after the crediting period comes to an end; and
- Ensure that measuring equipment is certified to national or international standards and calibrated according to the national standards and reference points or international standards and recalibrated at appropriate intervals according to manufacturer specifications.

16.2 Assessment of data and model applicability

At the time of Validation, the project owner shall document applicability of parameters and models used in Approach 2 or Approach 3 based on field

assessments. For each stratum, a representative number of small temporary soil pits (area of 50 by 50 cm) shall be dug to a depth of 50 cm. The resulting soil profiles are assessed regarding the following criteria:

1. Soil type and soil depth: Verify that the soil type and depth match data source's conditions.
2. Inorganic soil contents (rock, sand, clay etc.): Verify that portion of inorganic soil contents, match the data source's conditions. Especially increased presence of rocks or rock aggregates may require conservative adaptation of literature data and models (reduction of active soil components, density corrections, etc.).
3. Organic matter: Assess the presence of (pre-project) organic matter such as large diameter root residues (indicating e.g. previous woody crops or plantation use). If such residues are present, the project's pre-project soil carbon stock may be considerably higher than a C-depleted soil. The resulting reduction of potential SOC increase may require model adaptation or exclusion of areas from project.
4. Evidence for land management history: Assess soil structure for evidence of previous land management (e.g. tillage intensity and depth). Soil structure (e.g. upper soil horizons, porosity/compaction, disturbance depth, etc.) shall be in line with historic land management and literature source's practices.

The number of pits used for this assessment shall represent the project situation and distributed across the defined strata. In heterogeneous areas , e.g. with highly varying soils, land use history (e.g. fragmented historic deforestation) and/or management activities, the number of samples will have to be large enough to represent the variation and confirm the stratification.

The soil pits shall remain open until after the project initial certification audit. The VVB shall assess the adequacy of the sampling to confirm applicability of selected approaches and shall revisit a series of soil pits to verify the project owner's assessment. If applicability of selected approaches is in doubt, measurement of SOC in a sub-sample at this time is recommended.

The assessments described above are explicitly also required for projects claiming retrospective crediting. Despite the project activities having already taken place at initial certification, the above criteria will indicate applicability and adequacy of data/model choice.

16.3 Data and Parameters collected for baseline calculation and when project areas (farms/land parcels) are being added and at renewable of crediting period if required

The following baseline information on each project area (i.e. farm/land parcel) within the project region shall be recorded for any SOC Activity Module and project:

- Unique numerical identifier for each project area (i.e. farm/land parcel)
- Name of farm/land owner
- Physical address and GPS coordinates of locations
- A statement clarifying the ownership of emission reductions

Data/parameter:	A
Unit	ha
Description	Total project area
Source of data	Project owner records
Value(s) applied	
Measurement procedures	
Monitoring frequency	Project start
QA/QC procedures	
Additional comments	

Data/parameter:	A_y
Unit	ha
Description	Area per stratum y
Source of data	Project owner records
Value(s) applied	
Measurement procedures	
Monitoring frequency	Project start
QA/QC procedures	
Additional comments	

Data/parameter:	$AQ_{BL,ET,a}$
Unit	kg
Description	Agrochemical quantity applied by emitter type for baseline activities
Source of data	Project owner records (5year pre-project average current)
Value(s) applied	
Measurement procedures	
Monitoring frequency	Annually
QA/QC procedures	
Additional comments	

Data/parameter:	CY_{BL}
Unit	Kg/ha
Description	Average annual crop yield per ha in the project area during the baseline period (5 year average)
Source of data	Project owner records (self-reporting e.g. sale receipts, contracts, etc.)
Value(s) applied	

Measurement procedures	Yield is recorded annually and an average annual yield calculated across the 5-year baseline period
Monitoring frequency	Annually
QA/QC procedures	
Additional comments	

Data/parameter:	$SOC_{BL,y}$
Unit	tC/ha
Description	Soil organic carbon density at equilibrium per stratum y
Source of data	Project owner records (approach 1), from literature (approach 2) or modelled (approach 3)
Value(s) applied	
Measurement procedures	
Monitoring frequency	Project start
QA/QC procedures	
Additional comments	

Data/parameter:	$SOC_{REF,y}$
Unit	tC/ha
Description	Soil organic carbon reference density (under natural vegetation) at equilibrium per stratum y
Source of data	values from literature / local studies
Value(s) applied	
Measurement procedures	
Monitoring frequency	Project start
QA/QC procedures	
Additional comments	Used in approach 3 only

Data/parameter:	EF_{LE}
Unit	[tCO_2e kgN_{-1}]
Description	Conversion factor for emissions from N fertilizer
Source of data	IPCC defaults
Value(s) applied	Aggregated default value for EF_{FE} is 0.01. Disaggregated default values in IPCC 2019 Table 11.1 may be used if fertilizer inputs are known per fertilizer type.
Measurement procedures	
Monitoring frequency	Project start
QA/QC procedures	
Additional comments	Used for calculations of emissions from increased fertilizer use only. Not to be used under the SOC Framework Methodology for emission reductions

Data/parameter:	$F_{LU,y}$
Unit	[dimensionless]

Description	land use factor in stratum y
Source of data	IPCC defaults or national / local studies (preferred)
Value(s) applied	
Measurement procedures	
Monitoring frequency	Project start
QA/QC procedures	
Additional comments	

Data/parameter:	$F_{I,BL,y}$
Unit	[dimensionless]
Description	input factor before project start in stratum y
Source of data	IPCC defaults or national / local studies (preferred)
Value(s) applied	
Measurement procedures	
Monitoring frequency	Project start
QA/QC procedures	
Additional comments	

Data/parameter:	FE_{BL}
Unit	kg
Description	mean annual N fertilizer input under the baseline scenario
Source of data	Project owner records (5year pre-project average)
Value(s) applied	
Measurement procedures	
Monitoring frequency	Project start, if applicable
QA/QC procedures	
Additional comments	

Data/parameter:	$FUL_{BL,MT}$
Unit	litres
Description	Fossil fuel consumed recorded by vehicle and fuel type for baseline activities
Source of data	Project owner records or modelling (5year pre-project average)
Value(s) applied	
Measurement procedures	
Monitoring frequency	Project start, if applicable
QA/QC procedures	
Additional comments	

Data/parameter:	$EUW_{BL,SE}$
Unit	kWh

Description	electricity consumed by source for baseline activities
Source of data	Project owner records (5year pre-project average)
Value(s) applied	
Measurement procedures	
Monitoring frequency	Project start, if applicable
QA/QC procedures	
Additional comments	

In addition to the parameters listed above, the SOC Activity Modules may specify additional monitoring parameters depending on activity and calculation approach.

16.4 Data and Parameters monitored

Data/parameter:	A
Unit	ha
Description	Total project area
Source of data	Project owner records
Value(s) applied	
Measurement procedures	
Monitoring frequency	Annually
QA/QC procedures	
Additional comments	

Data/parameter:	A_y
Unit	ha
Description	Area per stratum y
Source of data	Project owner records
Value(s) applied	
Measurement procedures	
Monitoring frequency	Annually
QA/QC procedures	
Additional comments	

Data/parameter:	$AQ_{PR,ET,a}$
Unit	kg
Description	Agrochemical quantity by emitter type applied in year a
Source of data	Project owner records (current)
Value(s) applied	
Measurement procedures	
Monitoring frequency	Annually
QA/QC procedures	

Additional comments	

Data/parameter:	CY_t
Unit	Kg/ha
Description	Average annual crop yield per ha in the project area (5 year average)
Source of data	Project owner records (current)
Value(s) applied	
Measurement procedures	Yield is recorded annually and an average annual yield calculated at the end of each 5-year reporting period
Monitoring frequency	Annually
QA/QC procedures	
Additional comments	This value shall be reported as evidence that no yield reduction is taking place. The lowest annual yield is considered CY_{min} and serve as threshold to assess yield reduction (see Equation 19)

Data/parameter:	$SOC_{t,y}$
Unit	tC/ha
Description	Soil organic carbon density at equilibrium per stratum y
Source of data	Project owner records (approach 1), from literature (approach 2) or modelled (approach 3)
Value(s) applied	
Measurement procedures	
Monitoring frequency	At each performance certification
QA/QC procedures	
Additional comments	

Data/parameter:	$SOC_{REF,y}$
Unit	tC/ha
Description	Soil organic carbon reference density (under natural vegetation) at equilibrium per stratum y
Source of data	Same as in baseline
Value(s) applied	
Measurement procedures	
Monitoring frequency	Project start
QA/QC procedures	
Additional comments	Used in approach 3 only

Data/parameter:	$F_{LU,y}$
Unit	[dimensionless]
Description	land use factor in stratum y
Source of data	Same as in baseline
Value(s) applied	

Measurement procedures	
Monitoring frequency	Project start
QA/QC procedures	
Additional comments	

Data/parameter:	$F_{I,PR,y}$
Unit	[dimensionless]
Description	input factor before project start in stratum y
Source of data	IPCC defaults or national / local studies (preferred)
Value(s) applied	
Measurement procedures	
Monitoring frequency	Annually
QA/QC procedures	
Additional comments	

Data/parameter:	$FE_{PR,a}$
Unit	kg
Description	N fertilizer input under the project scenario in year a
Source of data	Project owner records (current)
Value(s) applied	
Measurement procedures	
Monitoring frequency	Annually, if applicable
QA/QC procedures	
Additional comments	

Data/parameter:	$FUL_{PR,MT,a}$
Unit	litres
Description	Fossil fuel consumed recorded by vehicle and fuel type in year a
Source of data	Project owner records (current)
Value(s) applied	
Measurement procedures	
Monitoring frequency	Annually, if applicable
QA/QC procedures	
Additional comments	

Data/parameter:	$EUW_{PR,SE,a}$
Unit	kWh
Description	electricity consumed by source in year a
Source of data	Project owner records (current)
Value(s) applied	

Measurement procedures	
Monitoring frequency	Annually, if applicable
QA/QC procedures	
Additional comments	

In addition to the parameters listed above, the SOC Activity Modules may specify additional monitoring parameters depending on SOC activity and calculation approach.

Annex 1: Eligible Soil Sampling Protocols

The soil sampling protocols listed in Table 6 have been accepted for use under this Framework Methodology. Additional sampling protocols may be submitted to Gold Standard for addition to this list, subject to review and acceptance by Gold Standard.

Table 6: List of eligible Soil Sampling Protocols

Protocol Name	Reference	Source (accessed 09/2019)
ICRAF protocol	Aynekulu, E. Vagen, T-G., Shephard, K., Winowiecki, L. 2011. A protocol for modeling, measurement and monitoring soil carbon stocks in agricultural landscapes. Version 1.1. World Agroforestry Centre (ICRAF), Nairobi.	http://old.worldagroforestry.org/downloads/Publications/PDFS/TM11192.pdf
VCS SOC Module	Verified Carbon Standard (VCS) 2011. Module VMD0021 Estimation of Stock in the Soil Carbon Pool (Version 1.0).	https://verra.org/methodology/vmd0021-estimation-of-stocks-in-the-soil-carbon-pool-v1-0/

Annex 2: Additional References

In addition to the references listed in section **Error! Reference source not found.**, the following sources were referred for the development of this methodology.

Aynekulu et al. (2011): A protocol for modeling, measurement and monitoring soil carbon stocks in agricultural landscapes, version 1.1. World Agroforestry Centre (ICRAF), Nairobi. (http://old.worldagroforestry.org/downloads/Publications/PDFS/TM11192.pdf)

Bikila, N. G., Tessema, Z. K., & Abule, E. G. (2016). Carbon sequestration potentials of semi-arid rangelands under traditional management practices in Borana, Southern Ethiopia. Agriculture, Ecosystems & Environment, 223, 108-114.

Cheesman, S., Thierfelder, C., Eash, N. S., Kassie, G. T., & Frossard, E. (2016). Soil carbon stocks in conservation agriculture systems of Southern Africa. Soil and Tillage Research, 156, 99-109.

European Soil Data Centre (2014): Soil data and information systems (http://eusoils.jrc.ec.europa.eu/). Also contains information on non-European soils.

FAO (2015): World reference base for soil resources 2014 International soil classification system for naming soils and creating legends for soil maps - Update 2015 (http://www.fao.org/3/i3794en/I3794en.pdf and http://www.fao.org/soils-portal/soil-survey/soil-classification/world-reference-base/en/)

Govaerts, B., Verhulst, N., Castellanos-Navarrete, A., Sayre, K. D., Dixon, J., & Dendooven, L. (2009). Conservation agriculture and soil carbon sequestration: between myth and farmer reality. Critical Reviews in Plant Science, 28(3), 97-122.

Hengl et al (2014): SoilGrids1km — Global Soil Information Based on Automated Mapping. PLOS ONE, DOI: 10.1371/journal.pone.0105992 (http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0105992).

Hoyle, F. C., D'Antuono, M., Overheu, T., & Murphy, D. V. (2014). Capacity for increasing soil organic carbon stocks in dryland agricultural systems. Soil Research, 51(8), 657-667.

IPCC (2006): Guidelines for National Greenhouse Gas Inventories, Volume 4
    Agriculture, Forestry and Other Land Use (http://www.ipcc-
    nggip.iges.or.jp/public/2006gl/vol4.html).

IPCC (2019): 2019 Refinement to the 2006 IPCC Guidelines for National
    Greenhouse Gas Inventories, Volume 4 Agriculture, Forestry and Other
    Land Use (https://www.ipcc-
    nggip.iges.or.jp/public/2019rf/pdf/19R_V4_advance.zip).

ISRIC (2014): World Soil Information (https://www.isric.org/explore). Several
    global soil maps are available, e.g. 1 km soil grids (http://soilgrids.org/).

Palm, C., Blanco-Canqui, H., DeClerck, F., Gatere, L., & Grace, P. (2014).
    Conservation agriculture and ecosystem services: An
    overview. Agriculture, Ecosystems & Environment, 187, 87-105.

Plaza-Bonilla, D., Arrúe, J. L., Cantero-Martínez, C., Fanlo, R., Iglesias, A., &
    Álvaro-Fuentes, J. (2015). Carbon management in dryland agricultural
    systems. A review. Agronomy for Sustainable Development, 35(4), 1319-
    1334.

Smith, P., Soussana, J. F., Angers, D., Schipper, L., Chenu, C., Rasse, D. P., &
    Arias-Navarro, C. (2019). How to measure, report and verify soil carbon
    change to realise the potential of soil carbon sequestration for
    atmospheric greenhouse gas removal. Global change biology.

VCS Methodology VM0017 v 1.0 (2011): Adoption of Sustainable Agricultural
    Land Management. Developed by BioCarbon Fund, World Bank.
    (https://verra.org/methodology/vm0017-adoption-of-sustainable-
    agricultural-land-management-v1-0/)

VCS Module VMD0021 v1.0 (2011): Module VMD0021 Estimation of Stock in the
    Soil Carbon Pool. (https://verra.org/methodology/vmd0021-estimation-of-
    stocks-in-the-soil-carbon-pool-v1-0/)