Gold Standard for the Global Goals

ACTIVITY MODULE METHODOLOGY

SOIL ORGANIC CARBON ACTIVITY MODULE FOR ZERO TILLAGE

SDG 13

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RELATED DOCUMENTS

– v. 1.0 Soil Organic Carbon Framework Methodology

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SUMMARY

This Soil Organic Carbon (SOC) Activity Module focuses on zero tillage/no-till practice, an agricultural technique for growing crops or pasture without mechanically disturbing the soil through tillage. It is applicable globally.

Zero tillage is an effective greenhouse gas (GHG) mitigation approach which accumulates and avoids emission of SOC (Ogle et al. 2005 and Derpsch et al. 2010). Cooper et al. (2021) assessed carbon change to a soil depth of 50 centimetres (cm) and demonstrated that long-term zero tillage has the dual benefits of mitigating potential soil carbon dioxide (CO_2) fluxes, increasing methane (CH_4) oxidation, and enhancing carbon storage through a reduction in soil porosity whilst reducing the risk of runoff during heavy rainfall through development of a highly effective, well-connected porosity. Ogle et al. (2019) report a sufficient amount of SOC in the topsoil to enhance the amount of SOC across the entire soil profile in sandy soils of tropical moist/wet, tropical dry, warm temperate moist, and cool temperate moist climates as well as loamy, silty, and clayey soils in tropical moist/wet, warm, and cool temperate moist climates.

Of particular significance to farmers is the role of long-term zero tillage in improving soil quality through:

- increased microbial biomass and earthworm activity (Cooper et al. 2021, Pelosi et al. 2009, Stroud, J. L. 2020),
- prevention of soil erosion (Nearing et al. 2017, Derpsch et al. 2010),
- improvement of the nutrient cycling (Triplett and Dick 2008),
- conservation of water in the soil through improving infiltration and reducing evaporation (Palm et al. 2014, Pittelkow et al. 2015a),
- creation of greater aggregate stability (Fernandez et al. 2010), and
- contribution to ensuring food security (Ogle et al. 2019).

In addition, GHG emissions are reduced through the decreased use of fossil fuels in field preparation.

In line with the Gold Standard for the Global Goals Soil Organic Carbon Framework Methodology (hereafter SOC Framework Methodology), this SOC Activity Module only accounts for benefits in the SOC pool. No other pools or emission reductions, e.g. in nitrous oxide (N_2O) due to reduced fertilizer need or reduced fossil fuel use, can be accounted for as benefits.

In the baseline situation, a farmer applies conventional or conservation tillage practices in which soil disturbance is caused by applying instruments such as harrows, mouldboard ploughs, offset harrows, subsoilers, and rippers for extensive seedbed preparation in a conventional tillage approach or less soil disturbance following a reduced tillage approach applying chisels, sweeps, and/or discs. The project introduces the zero tillage/no-till practice, which applies direct seeding of crops in a field without mechanical disturbance of the soil.

This SOC Activity Module is limited to two of the three approaches for quantification of SOC increase which are listed in the SOC Framework Methodology. Due to variability in research results on impacts of no-till on SOC, this SOC Activity Module focuses on Approach 1, which requires on-site measurements to directly document pre-project and project SOC stock levels. Nevertheless, more research findings, data, and proven modelling approaches are released daily for specific applications of zero tillage, and globally leading GHG and agricultural institutions such as the Intergovernmental Panel on Climate Change (IPCC),[1] the Food and Agricultural Organization (FAO)[2] of the United Nations, the World Resources institute (WRI),[3] the World Business Council for Sustainable Development (WBCSD),[4] and the European Conservation Agriculture Foundation (ECAF)[5] continue to promote zero tillage practices. Therefore, this SOC Activity Module also allows Approach 2, which applies project-specific datasets, parameters, and/or models to quantify baseline and project SOC stock levels, with strong requirements for application at the project level, including verification measurements for baseline and project impact. This SOC Activity Module does not allow Approach 3 (IPCC defaults) as described in the SOC Framework Methodology.

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[1] https://www.ipcc.ch
[2] https://www.fao.org/home/en/
[3] https://www.wri.org
[4] https://www.wbcsd.org
[5] https://ecaf.org

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1| DEFINITIONS

1.1.1 | Terms and definitions are listed in the SOC Framework Methodology and GS4GG Glossary. In addition, the following module-specific definitions apply:

Term	Definition
Zero Tillage/ No-Till	Zero tillage/no-till is an agricultural technique for growing crops or pasture without mechanically disturbing the soil through tillage (including disturbance from non-turning tillage such as rippers and disc harrows). Crop is sown directly into soil that has not been tilled since the harvest of the previous crop. This technique has more than 30% coverage of the soil surface with residues.
Conventional Tillage	Seedbed preparation using cultivation instruments such as harrows, mouldboard ploughs, offset harrows, subsoilers, and rippers. Conventional tillage methods, involving extensive seedbed preparation, cause the greatest soil disturbance and leave little plant residue on the surface.
Conservation Tillage	Conservation tillage includes any form of minimum or reduced tillage in which residue, mulch, or sod is left on the soil surface to protect soil and conserve moisture. After planting, at least 30% of the soil surface remains covered by residue to reduce soil erosion by water.

2| SCOPE, APPLICABILITY, AND ENTRY INTO FORCE

2.1 | SCOPE

2.1.1 | This activity module is applicable to project activities that introduces zero tillage/no-till practice, an agricultural technique for growing crops or pasture without mechanically disturbing the soil through tillage.

2.2 | APPLICABLITY

2.2.1 | Projects applying this SOC Activity Module shall comply with the applicability conditions that are specified below and are within the SOC Framework Methodology. In addition, projects shall comply with applicable Land Use & Forests Activity Requirements (hereafter LUF Activity Requirements) and the Gold Standard for the Global Goals Principles & Requirements (hereafter Principles & Requirements).

2.2.2 | Applicability conditions specific to this SOC Activity Module:

a. Geographic location – The activity module is applicable globally.

b. Project area –

   i. Generally, entire farms or selected fields/areas of a farm are eligible (see Section 4.1: Spatial Boundary).

ii. The methodology shall not be applicable to farms which have been applying zero tillage techniques in more than one full rotation cycle in the baseline period prior to project start, even if such application was on fields not included in the project. For single crop systems, baseline practices shall not include more than two subsequent years of zero tillage practices. In the baseline period, at least one tillage event (soil disturbance) shall be no less than two years prior to project start.

c. Zero tillage refers to practices on arable land for which no tillage is applied between harvest and sowing. Crop is sown directly into soil that has not been tilled since the harvest of the previous crop. At least 30% of the soil surface remains covered by residue to reduce soil erosion by water.

d. Soil type –

i. Proposed projects on sites with organic soils (Histosols), as defined by the World Reference Base for Soil Resources (FAO 2015), are ineligible. While no-till practices can reduce C losses from organic soils, they shall not commonly lead to an increase in soil carbon as targeted by this SOC Activity Module. Thus, only mineral soil types are eligible.

e. In line with the SOC Framework Methodology, any reduction in crop yield which can be attributed to the project activity shall be avoided. To date, the majority of studies report little or no difference in yield between the zero and conventional tillage managements (Shakoor et al. 2021, Huang et al. 2018). However, it has been reported that yields in the first one to two years following zero tillage implementation can decline (Pittelkow et al. 2015b). This SOC Activity Module thus requires monitoring whether the project activity impacts crop yields, calculated as the five-year average. Reductions of more than 5% in five-year average yield during the crediting period shall be accounted for as leakage (see Section 11). An exception to this may be allowed for reductions in the first three years after project start to allow refinement of practices, subject to review at verification.

f. In line with the SOC Framework Methodology, this SOC Activity Module only accounts for benefits in the SOC pool. No other pools or emission reductions (e.g. in N_2O due to reduced fertilizer need) can be accounted for as benefits.

g. No reversal to conventional or reduced tillage practices is allowed on the project area fields. This explicitly prohibits tillage rotation approaches applying periodic tillage runs between or after several years of zero tillage during the crediting period.

h. Organic carbon inputs to the field (other than on-field crop residue) shall not be changed as part of the project activity by more than 5% from baseline period average.
Exception: If this activity module is stacked with an additional Gold Standard methodology or activity module which uses the same quantification approach in the project (measurement or compatible SOC

model allowing distinction of impacts between zero tillage and organic inputs) and considers respective leakage effects, this applicability condition may be omitted.

i. If project activity includes change of other agricultural practices impacting SOC (e.g. cover crops, organic inputs), the same quantification approach (measurements and/or models) shall be used for all activities and shall be fully aligned to ensure that overall benefits are quantified correctly and not double-counted.

j. Application of herbicides to prepare fields and/or terminate crops shall be minimized, and negative environmental impacts shall be prevented, in accordance with Gold Standard Principle 9.6. Use of herbicides related to project activities, specifically for crop termination and weed control, shall not be increased by more than 5% from baseline period average.

2.3 | ENTRY INTO FORCE

2.3.1 | The date of entry into force of this activity module is dd/02/2024.

3| ADDITIONALITY

3.1.1 | The regulatory surplus shall be demonstrated by all the projects, irrespective of scale. The project shall demonstrate that proposed activity is neither directly mandated by law nor otherwise triggered by legal requirements (e.g., legally binding agreements, covenants, consent decrees, or contracts (with government agencies or private parties). If such legal requirements are identified, then crediting for the activity shall only be allowed until the date the legal requirements take effect.

3.1.2 | All projects seeking Gold Standard certification shall demonstrate that they would not have been implemented without the benefits of carbon revenue. Specific rules and guidelines on how to assess additionality can be found in the Additionality section in the latest version of the Gold Standard SOC Framework Methodology..

4| PROJECT BOUNDARIES

4.1 | Spatial Boundary

4.1.1 | For spatial boundaries, the rules and requirements defined in the SOC Framework Methodology apply.

4.1.2 | Spatial boundary description specific to this SOC Activity Module:

a. Generally, entire farms or selected fields/areas of a farm are eligible. If project activities are only implemented on selected fields, all applicability conditions and requirements from the SOC Framework Methodology and from this SOC Activity Module shall be applied to these specific fields. These fields shall remain in the project during the entire crediting period (i.e. no change of participating fields within a farm during the crediting period is allowed).

b. This SOC Activity Module requires GHG sources, sinks, and reservoirs (SSR) as identified in Figure 4-01 to be considered, with a focus on their impact on SOC and increase of emissions from project activities. The boundary thus includes all impacted field activities (machine use, tillage, and application of fertilizer and pesticides). Since SOC increase from zero tillage is also driven through inputs of biomass (root and residue), residue management for all crops is essential to assess SOC impact. For the same reason, other organic inputs (e.g. manure, compost) have to be monitored. Since no changes are expected to be made to farm infrastructure or handling of main crops, these activities are not included in the project boundary for quantification.

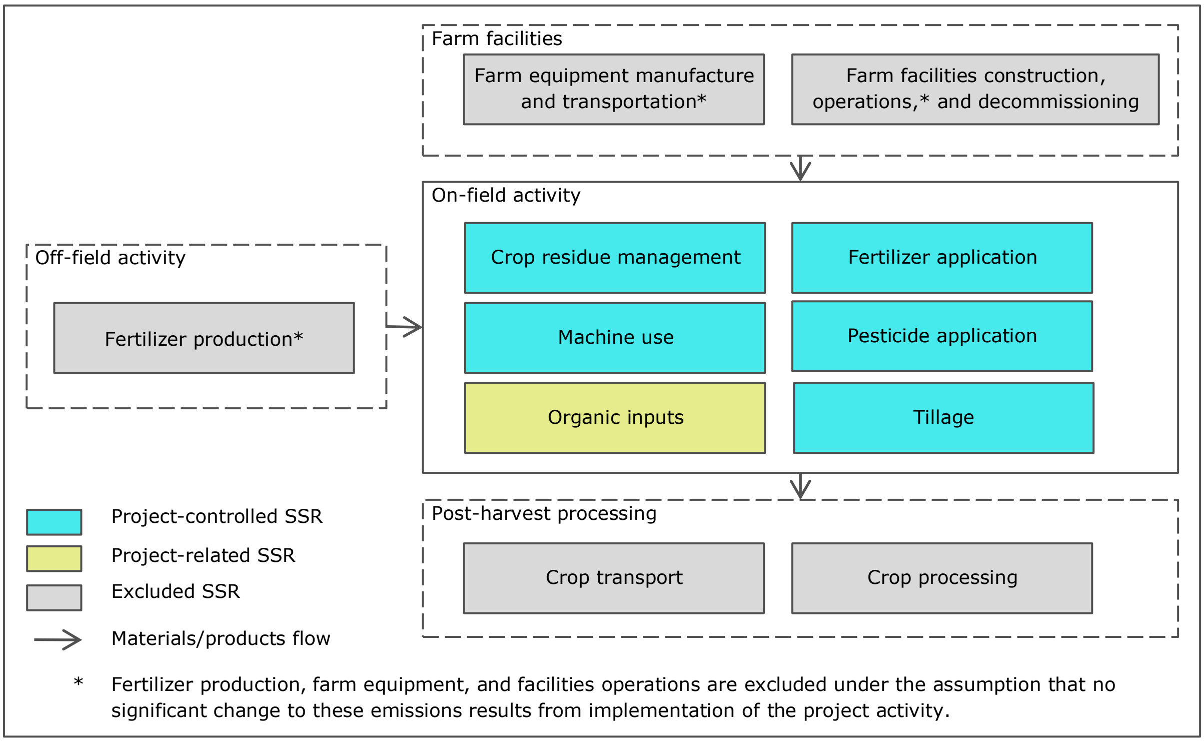

Figure 4-01: Spatial project boundary

4.2 | Temporal Boundary

4.2.1 | The maximum crediting period allowed under this Activity Module is 10 years The crediting period renewal at the end of 5th year is required as per Principles and requirements.

4.3 | Carbon Pools

4.3.1 | Carbon pool description:

a. In line with the SOC Framework Methodology, this SOC Activity Module only accounts for benefits in the SOC pool. Additional pools (e.g. biomass and litter) may be used for calculation of SOC change, but no GHG sequestration in pools other than soil carbon shall be accounted for as benefits.

b. No emission reduction from other GHG sources (e.g. fossil fuel use or fertilizer application) shall be reported for benefits under this methodology. To account for emission reductions from reduced fuel use or fertilizer application, a separate Gold Standard methodology may be applied.

4.4 | Greenhouse Gases

4.4.1 | Following the SOC Framework Methodology, all GHG sinks and sources affected by its activities shall be monitored.

4.4.2 | For this SOC Activity Module, this specifically includes any significant increases in CO_2, CH_4, and N_2O emissions from project activities.

5| EMISSION REDUCTION QUANTIFICATION APPROACH

Calculations for overall benefits follow the equations set out in the Emissions Reduction Quantification Approaches section of the SOC Framework Methodology. Sections below describe the approaches and calculations specific to this SOC Activity Module.

5.1 | Approaches for Baseline and Project Scenario Quantification

5.1.1 | This SOC Activity Module allows application of quantification Approaches 1 and 2, as described in the SOC Framework Methodology. It does not allow application of Approach 3 (default equations and parameters). Project developers shall select the most specific approach possible with the data available, as outlined in the decision tree in Figure 2 of the SOC Framework Methodology.

5.2 | Approach 1 (On-Site Measurements of SOC)

5.2.1 | Additional requirements:

a. SOC measurements shall be taken at a suitable time of year, e.g. at the beginning of the season for main crops, with repeated measurements performed at the same time of year to avoid bias due to short-term variation in soil carbon pools. The project documentation shall specify the timing of soil sampling, i.e. the season and crop rotation phase, as applicable, to be implemented by all farms participating in the project or program.

b. To avoid overestimation of SOC stocks, measurements shall always be performed *before* any significant carbon inputs, such as organic or partially organic fertilizers, including compost and manure, as well as other carbon sources (e.g. in lime or other soil inputs).

c. In line with the SOC Framework Methodology, soil samples shall be collected to a depth of 50 cm.

d. Since sampling constitutes a disturbance in the zero tillage field, the project description shall include an approach to avoid repeated sampling at the same position (e.g. by adequately marking sampling sites after closure or recording exact GPS coordinates and prescribing a minimum distance for the next sampling round).

e. As introduction of zero tillage practices can lead to soil compaction, bulk density must be considered in all quantification approaches. Quantification is to be done on an equivalent mass basis to properly quantify carbon impacts, i.e. if increased bulk density is measured in the project scenario, respective layer depth shall be reduced proportionally when calculating SOC change.

f. Special care shall be taken to ensure that superficial litter (crop residue) is not included in the SOC quantification.

5.2.2 | Alternative SOC quantification approaches beyond physical sampling and chemical laboratory analysis, such as proximal sensing (in situ) or lab spectroscopy approaches may be used in projects if such approaches are approved by Gold Standard at the level of Activity Requirement. Application of such SOC quantification is subject to scientific proof that the results obtained under project conditions[6] do not show significant differences to the laboratory results to a soil depth of 50 cm. Revalidation of measurements in the project area shall be undertaken in accordance with LUF Activity Requirements.

If a new technology has not been tested under comparable conditions, a project may establish project-specific datasets to test the accuracy of the technology. This testing shall include repeated SOC stock measurements in at least two points in time, with each sample quantified with the new technology and parallel laboratory analysis. If a system (re)calibration is needed, separate datasets shall be used for calibration of the technology and validation for the project site. Upon confirmation of accuracy for measurements with the new technology, the project shall request a design change and get approval from Gold Standard to start using the alternative technology (subject to potential additional guidance in LUF Activity Requirements). After confirmation by Gold Standard, the project may use the new technology for quantification.

In any case, uncertainty of the SOC quantification under project conditions shall have to be considered according to Gold Standard Uncertainty Requirements and following an Uncertainty Assessment as outlined in the SOC Framework Methodology.

[6] Refer to stratification criteria (Section 7.1.4) for factors determining applicability to project conditions. All factors listed for stratification shall be assessed to confirm applicability.

5.3 | Approach 2 (Application of Models, Research data)

5.3.1 | Additional requirements:

a. Project developers shall provide evidence that calculation approaches, datasets, parameters, and models from peer-reviewed publications to estimate baseline and project SOC stocks in the project are conservative and applicable to the project site conditions and management practices.[7]

b. Models and datasets applied must be calibrated locally, i.e. using project-specific data. Global models without such local parametrization and validation shall not be applied. Application of global defaults for soil respiration, e.g. Q_{10} values to quantify temperature effects on respiration, is not allowed.

c. Project documentation shall include evidence that the sources used are applicable to main crops and levels of yield (production intensity) as well as management practices (including tillage practice) in the project area for baseline and project scenarios. Evidence shall also be provided that datasets and models have sufficient temporal resolution (i.e. multiple data points per year) to account for impacts of seasonal variations in practices and other factors such as changing weather conditions.

d. Parameters for process-based models shall be calibrated and verified following best practice, using at least five years of data for calibration and three years of independent data for verification. Both calibration and verification datasets shall match project conditions as outlined above. Any gaps in datasets and procedures how gaps were addressed for the model calibration and verification shall be reported at validation.

e. SOC measurements for a representative sample in each stratum of the project area shall be made at project start and at least once every five years, applying proven methodology (see Section 5.2.2) and used to statistically assess model results or research data used for quantification. If significant differences from modelled results or research data are found, the models shall be refined.

[7] Refer to stratification criteria (Section 7.1.4) for factors determining applicability to project conditions. All factors listed for stratification shall be assessed to confirm applicability.

6| BASELINE SCENARIO

6.1 | Baseline Calculations

6.1.1 | Quantification for SOC in the baseline ($SOC_{BL,y}$) shall follow the rules, approaches, calculations, and parameters set out in the Baseline Scenario section of the SOC Framework Methodology.

6.1.2 | Baseline data is required for five years as required by the SOC Framework Methodology. If five-year baseline data is not fully available for a field within a stratum (e.g. as it was leased less than five years prior to project start), evidence shall be provided that average baseline conditions for the stratum apply to the field lacking data, referencing the stratification criteria described below.

6.1.3 | Baseline period may be extended to cover full rotation periods; respectively avoid including fragments of rotations in the baseline quantification (e.g. in a three-year crop rotation system, a six-year baseline period shall deliver more consistent results, including all relevant practices, inputs and crop yields for two full rotation periods).

6.1.4 | To determine the baseline of the eligible project area, the land shall be stratified into modelling units (MUs) according to criteria set out in Section 6 of the SOC Framework Methodology. In addition, the following criteria shall be considered in stratification:

- Mineral soil type
- Tillage practices (e.g. tillage depth, frequency, tillage equipment)
- Specific crops (or crop rotations) and production periods

For each stratum, SOC measurements shall be performed (Approach 1) and/or model parameters identified and verified (Approach 2).

6.1.5 | If a model is used to quantify baseline SOC (Approach 2), full transparency shall be provided on input data, parametrization, and quantification approach. Application of "black box" models is not allowed.

7| PROJECT SCENARIO

7.1 | Project Calculations

7.1.1 | Quantification for SOC in the project scenario ($SOC_{t,y}$) shall follow the rules, approaches, calculations, and parameters set out in the Project Scenario section of the SOC Framework Methodology.

7.1.2 | This SOC Activity Module addresses change to zero tillage practices. Quantifications shall consider all changes in practices (including changes to crop management, fertilization, and application of other agrochemicals). For model application (Approach 2), calculation and parameter must be adapted to the specific project situation.

7.1.3 | If other agricultural activities besides zero tillage are introduced in a project (e.g. cover crops, organic inputs), interactions shall be considered by applying the same SOC quantification approaches (Approach 1 or 2). If models are applied (Approach 2), they shall specifically cover all activities in the project scenario.

7.1.4 | For the project scenario, the eligible project area shall be stratified into MUs according to criteria set out in Section 7 of the SOC Framework Methodology. In addition, the following criteria shall be considered in stratification.

- Mineral soil type
- Tillage practices (zero tillage)
- Specific crops (or crop rotations) and production periods

For each stratum, SOC measurements shall be performed (Approach 1) and/or model parameters identified and verified (Approach 2).

7.1.5 | If a model is used to quantify project SOC (Approach 2), full transparency shall be provided on input data, parametrization, and quantification approach. Application of "black box" models is not allowed.

8| PROCEDURES FOR CALCULATION APPROACH CHANGE

8.1.1 | Any approach change between baseline and project scenario calculations shall be in compliance with requirements of section 8: Procedure for approach change of SOC Framework Methodology.

9| UNCERTAINTY

9.1.1 | Calculation of uncertainty shall follow the rules and equations set out in the SOC Framework Methodology.

9.1.2 | If no information on Standard deviation (SD) or Standard error (SE) is known for a parameter, SE of 50% of the parameter value shall be assumed. For the calculations of the upper and lower confidence intervals, a t-value of 3 shall be applied. Exceptions to this rule are accepted default values considered constant (e.g. physical conversion rates, global warming potentials).

10| OTHER EMISSIONS

10.1 | Project emissions

10.1.1 | Significant additional GHG emissions (>5% total) due to the project activity need to be accounted for. For this SOC Activity Module, this explicitly includes increased fertilizer input, fuel and electricity use, and other agrochemical emissions (*AE*).

10.1.2 | As such emissions may differ between strata, calculation for this SOC Activity Module shall follow the rules and Equations 1 through 7 that are described below, which replace the area-wide calculation set out in Equations 12 through 18 of the SOC Framework Methodology. They follow the same approach but allow application of different emission factors and quantities for different strata.

$$PE_{t-0} = \Delta FE_{t-0} + \Delta FU_{t-0} + \Delta AE_{t-0} \quad (1)$$

Where:

PE_{t-0}	=	*emissions from project activities in the calculation period [tCO_2e]*
ΔFE_{t-0}	=	*emissions from increased fertilizer use in the calculation period [tCO_2e]*
ΔFU_{t-0}	=	*emissions from increased fuel and electricity use in the calculation period [tCO_2e]*
ΔAE_{t-0}	=	*other agrochemical emissions in the calculation period [tCO_2e]*

10.2 | Increased Nitrogen Fertilizer Input

10.2.1 | 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. This equation shall not be applied for reductions in N fertilizer input, in which case ΔFE_{t-0} is considered 0. To account for reductions in fertilizer input and the respective GHG emissions reductions, a separate Gold Standard methodology shall be applied.

$$\Delta FE_{t-0} = \sum_y \left[EF_{FE,y} \times \sum_{a=1}^{T} \left(FE_{PR,y,a} - FE_{BL,y} \right) \right] \quad (2)$$

Where:

ΔFE_{t-0}	=	*emissions from increased fertilizer use in the calculation period [tCO_2e]. Must be ≥ 0 in this methodology (i.e. no accounting of reductions).*
$FE_{PR,y,a}$	=	*N fertilizer input in stratum y under the project scenario in year a of the calculation period [kgN]*
$FE_{BL,y}$	=	*mean annual N fertilizer input in stratum y under the baseline scenario [kgN]*
T	=	*number of years in the calculation period [yr]*
$EF_{FE,y}$	=	*Conversion factor for emissions from N fertilizer in stratum y [tCO_2e kgN^{-1}]. IPCC 2019 aggregated default value[8] 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 developer. For FE_{BL}, mean annual input is calculated based on respective management records for five years prior to project start. If no adequate documentation can be provided, FE_{BL} shall be no more than 50% of FE_{PR}.

[8] IPCC 2019, Vol 4 AFOLU, Table 11.1 (Aggregated default value)

10.3 | Increased Combustion of Fossil Fuels and Electricity Use

10.3.1 | 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 developer can demonstrate that the 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.

$$\Delta FU_{t-0} = \sum_{y}\left[\sum_{a=1}^{T}\left(FU_{PR,y,a} - FU_{BL,y}\right) + \left(EU_{PR,y,a} - EU_{BL,y}\right)\right] \quad (3)$$

Where:

ΔFU_{t-0} = *emissions from increased fossil fuel and electricity use in the calculation period [tCO_2e]*

$FU_{PR,y,a}$ = *emissions from use of fossil fuels in stratum y under the project scenario in year a of the calculation period [tCO_2e]*

$FU_{BL,y}$ = *mean annual emissions from use of fossil fuels in stratum y under the baseline scenario [tCO_2e]*

$EU_{PR,y,a}$ = *emissions from use of electricity in stratum y under the project scenario in year a of the calculation period [tCO_2e]*

$EU_{BL,y}$ = *mean annual emissions from use of electricity in stratum y under the baseline scenario [tCO_2e]*

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

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

$$FU_{i,y,a} = \sum_{MT} FUL_{i,y,MT,a} \times FEF_{i,y,MT} \quad (4)$$

Where:

$FU_{i,y,a}$ = *emissions from use of fossil fuels in stratum y in year a [$tCO_2e\ ha^{-1}$]*

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

$FEF_{i,y,MT}$ = *emissions factor for the fuel used in stratum y in machinery MT [$tCO_2e\ litres^{-1}$]*

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 five 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 kilometres (km), l/tonne-km, l/hour) of the vehicle and the appropriate unit of use for the selected fuel efficiency (e.g. 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.

10.3.3 | EU_{PR} and EU_{BL} shall be documented by the project developer 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 shall be calculated instead, following the approach described above.

$$EU_{i,y,a} = \sum_{SE} EUW_{i,y,SE,a} \times EEF_{i,y,SE} \quad (5)$$

Where:

$EU_{i,y,a}$ = *emissions from electricity consumption in stratum y in year a [tCO_2e ha^{-1}]*

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

$EEF_{i,y,SE}$ = *emissions factor for the electricity used in stratum y in source SE [tCO_2e 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 five years prior to project start. If no adequate documentation can be provided, EU_{BL} shall be no more than 50% of EU_{PR}.

10.4 | Other Agrochemical Emissions

10.4.1 | Additional *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 developer 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.

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

$$\Delta AE_{t-0} = \sum_{y}\left[\sum_{a=1}^{T}\left(AE_{PR,y,a} - AE_{BL,y}\right)\right] \quad (6)$$

Where:

ΔAE_{t-0} = *additional emissions from project activity in the calculation period [tCO_2e]*

$AE_{PR,y,a}$ = *other emissions in stratum y under the project scenario in year a of the calculation period [tCO_2e]*

$AE_{BL,y}$ = *other emissions (annual mean) in stratum y under the baseline scenario [tCO_2e]*

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

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

$$AE_{i,y,a} = \sum_{ET} AQ_{i,y,ET,a} \times AEF_{i,y,ET} \quad (7)$$

Where:

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

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

$AEF_{i,y,ET}$ = *emissions factor of the agrochemical used in stratum y (for emitter type ET) [$tCO_2e\ kg^{-1}$]*

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

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

10.4.4 | For AE_{BL}, mean annual emissions are calculated based on respective management records for five 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

11.1.1 | Calculation of leakage shall follow the rules and equations set out in the SOC Framework Methodology. If a reduction in yield is detected in a performance certification, it is assumed that the lost production capacity has to be made up for on land outside the project area. Emissions caused by such a shift shall be accounted for as leakage according to the equation listed in the SOC Framework Methodology. Note that accounting of positive leakage is not allowed according to the SOC Framework Methodology.

11.1.2 | Additional requirements: Under this SOC Activity Module, leakage shall be assessed at stratum level. Instead of Equation 19 in the SOC Framework Methodology, leakage shall thus be calculated for each stratum separately, using Equation 8:

$$\mathrm{LK}_{t-0} = \sum_y \left[max\left[\frac{CY_{min,y} - CY_{t,y}}{CY_{BL,y}}; 0\right] \times \bar{A}_{y,t} \right] \times \left(\Delta \mathrm{BC}_{LA} + \Delta SOC_{LA,t-0} + \Delta FE_{LA,t-0} + \Delta FU_{LA,t-0}\right) \quad (8)$$

Where:

LK_{t-0} = *emissions due to shift of production to non-project lands (leakage area) [tCO_2e]*

$CY_{t,y}$ = *crop yield in stratum y at time t (five-year average*) [kg ha^{-1}]*

$CY_{min,y}$ = *lowest crop yield (five-year average**) in stratum y in any calculation period since project start [kg ha^{-1}]*

$CY_{BL,y}$ = *crop yield in stratum y under the baseline scenario (five-year average*) [kg ha^{-1}]*

$\bar{A}_{y,t}$ = *eligible project area in stratum y (five-year average*) [ha]*

ΔBC_{LA} = *emissions from change in biomass carbon stocks in leakage area [tCO$_2$e ha^{-1}]*

$\Delta SOC_{LA,t-0}$ = *emissions from change in SOC stocks in leakage area [tCO$_2$e ha^{-1}]*

$\Delta FE_{LA,t-0}$ = *change in emissions from use of fertilizer in leakage area [tCO$_2$e ha^{-1}]*

$\Delta FU_{LA,t-0}$ = *change in emissions from fuel use in leakage area [tCO$_2$e ha^{-1}]*

* *If the baseline period is extended to cover full rotation cycles, crop yield and stratum area shall be calculated as the average across an equal length period. In the project scenario, the five-year average shall be calculated as a running average from year t-4 to year t (for longer baseline periods, averaging period shall be increased accordingly).*

** *Baseline years shall be in included in CY_{min} for the project period (i.e. in project year 1, CY_{min} = CY_{BL}).*

12| MONITORING

12.1.1 | Monitoring approach and parameters shall be followed as set out in the SOC Framework Methodology. Also, the project developer shall collect and document evidence that this SOC Activity Module's applicability conditions are met at all times and that project activity has been implemented as stated, specifically that no tillage events have occurred. Acceptable evidence are detailed field reports listing key interventions, dates and machinery used, remote sensing analysis of vegetation, and crop residue cover or time-stamped photographs of fields before, during, and after the cropping season, including fallow periods as applicable.

12.1.2 | Additional requirements: The following parameters shall be monitored in this SOC Activity Module, depending on the quantification approach selected. Where the parameters listed below overlap with the SOC Framework Methodology Monitoring section, the below descriptions shall be applied under this SOC Activity Module to ensure stratum-level quantification and appropriate data sources.

a. Data and Parameters fixed:

12.1.3 | Data and parameters collected for baseline calculation, when project areas (farms/land parcels) are being added, and at renewable of crediting period if required:

Data/parameter:	*$CY_{BL,y}$*
Unit	kg ha^{-1}
Description	Average annual crop yield per hectare (ha) in stratum y in the project area during the baseline period (five-year average*)
Source of data	Farm records, e.g. field records, sales receipts
Value(s) applied	-
Measurement procedures	Yield is recorded for each crop season and accumulated annually (as sum of each crop type). For the baseline, an average annual yield is calculated across the five-year baseline period.* * If the baseline period is extended to cover full rotation cycles, crop yield shall be calculated as the average across an equal length period. In the project scenario, the five-year average shall be calculated as a running average from year t-4 to year t (for longer baseline periods, averaging period shall be increased accordingly).
Monitoring frequency	Project start
QA/QC procedures	-
Additional comments	Used in Equation 8. This parameter replaces parameter CY_{BL} in the SOC Framework Methodology (Equation 19).

Data/parameter:	*$EF_{FE,y}$*
Unit	tCO_2e kgN^{-1}
Description	Conversion factor for emissions from N fertilizer in stratum y
Source of data	IPCC 2019
Value(s) applied	IPCC 2019 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 in Equation 2

Data/parameter:	*$FE_{BL,y}$*
Unit	kgN
Description	Mean annual N fertilizer input in stratum y under the baseline scenario
Source of data	Farm records (field level)
Value(s) applied	Average annual N input in stratum y, calculated across baseline period (five years)
Measurement procedures	
Monitoring frequency	Project start
QA/QC procedures	Used in Equation 2

b. Data and Parameters monitored

Data/parameter:	$\bar{A}_{y,t}$
Unit	ha
Description	Eligible project area in stratum y at time t (five-year average*)
Source of data	Farm records (GPS data, GIS files)
Value(s) applied	
Measurement procedures	Documentation allowing unambiguous identification and documenting area size at field level * If the baseline period is extended to cover full rotation cycles, area shall be calculated as the average across a period of equal length.
Monitoring frequency	Annually (for calculation of five-year average*)
QA/QC procedures	
Additional comments	Used in Equation 8

Data/parameter:	$AQ_{i,y,ET,a}$
Unit	km
Description	Quantity of agrochemicals in stratum y for emitter type (ET) applied in year a
Source of data	Farm records
Value(s) applied	
Measurement procedures	Documentation of quantity and type of non–N fertilizer agrochemicals used for zero tillage (e.g. for crop termination, weed control)
Monitoring frequency	Annually
QA/QC procedures	
Additional comments	Used in Equation 7

Data/parameter:	$AEF_{i,y,ET}$
Unit	$tCO_2e\ kg^{-1}$
Description	Emissions factor of the agrochemical used in stratum y (for emitter type [ET])
Source of data	Supplier information
Value(s) applied	
Measurement procedures	Supplier's life cycle assessment (LCA) information for production and transport. If no supplier information is available, national or international default values may be applied.
Monitoring frequency	Annually
QA/QC procedures	
Additional comments	Used in Equation 7

Data/parameter:	$CY_{t,y}$
Unit	kg ha^{-1}
Description	Average annual crop yield per ha in stratum y in the project area (five-year average*)
Source of data	Farm records, e.g. field records, sales receipts
Value(s) applied	
Measurement procedures	Yield is recorded for each crop season and cumulated annually (as sum of each crop type). Average annual yield is calculated for each stratum across the five-year reporting period.* * If the baseline period is extended to cover full rotation cycles, crop yield shall be calculated as the average across a period of equal length.
Monitoring frequency	Annually (for calculation of five-year average*)
QA/QC procedures	
Additional comments	Used in Equation 8. This parameter replaces parameter CY_t in the SOC Framework Methodology (Equation 19).

Data/parameter:	$CY_{min,y}$
Unit	Kilogram (kg) ha^{-1}
Description	Minimum annual crop yield per ha in stratum y since project start
Source of data	Farm records, e.g. field records, sales receipts
Value(s) applied	
Measurement procedures	Yield is recorded for each crop season and cumulated annually (as sum of each crop type). $CY_{min,y}$ represents lowest average annual yield per stratum ($CY_{t,y}$) since project start and serves as threshold to assess yield reduction. Note: As the running average yield ($CY_{t,y}$) also includes baseline years, $CY_{min,y}$ for project year one is equal to CY_{BL}.
Monitoring frequency	At verification
QA/QC procedures	
Additional comments	Used in Equation 8. This parameter replaces parameter CY_{min} in the SOC Framework Methodology (Equation 19).

Data/parameter:	ΔBC_{LA}
Unit	$tCO_2e\ ha^{-1}$
Description	Emissions from change in biomass carbon stocks in leakage area
Source of data	Remote sensing analysis or public data on leakage area
Value(s) applied	
Measurement procedures	Emissions from change in biomass are calculated as the expected difference between pre-leakage carbon stocks and post-leakage carbon stocks (e.g. deforestation or removal of woody biomass due to intensification) in the leakage area. Loss of carbon shall be accounted for as tons of CO_2 equivalent released. In line with the requirement in the SOC Framework Methodology that no positive leakage must be accounted, no increase in biomass in the leakage area shall be accounted for.
Monitoring frequency	At verification
QA/QC procedures	
Additional comments	Used in Equation 8

Data/parameter:	$\Delta SOC_{LA,t-0}$
Unit	$tCO_2e\ ha^{-1}$
Description	Emissions from change in SOC stocks in leakage area
Source of data	Remote sensing analysis or public data on leakage area
Value(s) applied	
Measurement procedures	Emissions from change in SOC stocks are calculated as the expected difference between pre-leakage SOC stocks and post-leakage SOC stocks (e.g. loss in SOC due to tillage or other agricultural practices) in the leakage area. Loss of SOC shall be accounted for as tons of CO_2 equivalent released. In line with the requirement in the SOC Framework Methodology that no positive leakage must be accounted, no increase in SOC in the leakage area shall be accounted for.
Monitoring frequency	At verification
QA/QC procedures	
Additional comments	Used in Equation 8

Data/parameter:	*$EEF_{i,y,SE}$*
Unit	$tCO_2e\ kWh^{-1}$
Description	Emissions factor for the electricity used in stratum y in electricity source type
Source of data	a) If the electricity supply source is a regional/national electric grid, apply the provisions of the latest version of TOOL05. b) If the electricity supply source is a mini grid, apply the provisions of the latest version of "AMS-I.F.: Renewable electricity generation for captive use and mini-grid". c) If the electricity supply source is a renewable energy captive power plant, a value of 0 tCO2/MWh shall be applied. d) For fossil-based captive sources, use national GHG inventory sources such as: • USA: Emission Factors for Greenhouse Gas Inventories (epa.gov) • EU: EMEP/EEA air pollutant emission inventory guidebook 2019 — European Environment Agency (europa.eu) and EMEP/EEA air pollutant emission inventory guidebook 2023 (europa.eu) • If no national data is available, default emission factors in IPCC 2006 Volume 2, Chapter 3, Table 3.3.1 may be applied (taking into account listed uncertainties).
Value(s) applied	
Measurement procedures	
Monitoring frequency	Project start, annual review for national updates
QA/QC procedures	
Additional comments	Used in Equation 5

Data/parameter:	*$EUW_{i,y,SE,a}$*
Unit	kWh
Description	Electricity consumption in stratum y from source SE in year a
Source of data	Farm records
Value(s) applied	
Measurement procedures	1) Document electric equipment and power source used for zero tillage practices in each stratum. 2) Quantify electricity used for zero tillage activity based on: a. direct records (electricity documentation), or b. duration of equipment use (hours) and power consumption per equipment type (kWatt).
Monitoring frequency	Annually: use-based documentation, aggregated (sum) per year
QA/QC procedures	
Additional comments	Used in Equation 5

Data/parameter:	*$FE_{PR,y,a}$*
Unit	kgN
Description	N fertilizer input in stratum y under the project scenario in year a
Source of data	Farm records (field level)

Value(s) applied	Sum of N inputs in stratum y in year a
Measurement procedures	
Monitoring frequency	Use-based, aggregated annually
QA/QC procedures	
Additional comments	Used in Equation 2

Data/parameter:	$FEF_{i,y,MT}$
Unit	tCO_2e liter^{-1}
Description	Emissions factor for the fuel used in stratum y in machinery type (MT)
Source of data	a) National GHG inventory sources such as: • USA: Emission Factors for Greenhouse Gas Inventories (epa.gov) • Canada: Emission_Factors.pdf (ec.gc.ca) • EU: EMEP/EEA air pollutant emission inventory guidebook 2019 — European Environment Agency (europa.eu) and EMEP/EEA air pollutant emission inventory guidebook 2023 (europa.eu) b) If no national data is available, default emission factors in IPCC 2006 Volume 2, Chapter 3, Table 3.3.1 may be applied (taking into account listed uncertainties).
Value(s) applied	
Measurement procedures	
Monitoring frequency	Project start, annual review for national updates
QA/QC procedures	
Additional comments	Used in Equation 4

Data/parameter:	$FUL_{i,y,MT,a}$
Unit	Liter
Description	Fuel consumption in stratum y by the machinery type (MT) used in year a
Source of data	Farm records
Value(s) applied	
Measurement procedures	1) Document machines and fuel type for equipment used for zero tillage practices in each stratum. 2) Document amount of equipment use for zero tillage from: a. direct records (fuel use), or b. equipment usage (hours or distance) and fuel consumption (litres/hour or litres/km).
Monitoring frequency	Baseline: project start Project: use-based documentation, aggregated (sum) per year
QA/QC procedures	
Additional comments	Used in Equation 4

13| REFERENCES

13.1.1 |In addition to the methodologies, methodological tools, guidelines, and key sources listed in the SOC Framework Methodology, this SOC Activity Module refers to the following key publications:

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DOCUMENT HISTORY

Version	Release date	Description
1.0	20/02/2024	First release