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METHODOLOGY

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SDG 13

MICROBIAL CARBON DI-OXIDE MINERALISATION

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SUMMARY

This methodology applies to project activities that remove and durably store carbon dioxide (CO_2) by applying a microbial inoculant to existing cropland. This approach leverages the mutualistic relationship of beneficial soil bacteria and plant roots to capture CO_2 and convert it into soil inorganic carbon (SIC). This methodology prescribes requirements and guidance to quantify and monitor the emissions removals associated with the eligible activities. The crediting period shall be a maximum of 10 years.

This methodology is globally applicable to a wide variety of crops and across several soil types and climate zones. It is not applicable to wetlands, grasslands, irrigated land, or forest. The microbial inoculant(s) shall be registered with the appropriate agricultural authority and shall not have an adverse effect on human, animal, or plant health, safety, or the environment, under reasonably foreseeable conditions of storage or use.

Project developers should select crop types that meet the methodology requirements and are suitable for the project geography. Before the project begins, the ability of the microbial inoculant to fix CO_2 from the atmosphere with selected crop types should be demonstrated in lab and field studies. The project developer shall assess the time period for SIC generation to occur in the microbial inoculant of interest and select a crop with a life cycle longer than that time period. The project developer shall decide optimal application rates for the microbial inoculant based on lab studies, field trials, and/or peer-reviewed scientific research.

The application of this methodology shall not involve any change in field management practices that could lead to increased greenhouse gas (GHG) emissions (e.g., increased synthetic fertiliser application, deeper tilling, increased manure application, crop residue burning). Changes that enhance sustainability (e.g., adoption of cover crops, transition to no-till) are permitted, provided these practices are implemented equally on the treated units and their corresponding baseline units. The baseline scenario is the

continuation of standard agricultural practices without the application of a microbial inoculant for increasing SIC. Untreated sample locations (i.e., baseline units) are used to represent SIC generation in the absence of project activities. For projects using this methodology, it is recommended that the baseline area represents at least 5% of the total project area. These baseline units may relate to an entire field or part of a field.

ACKNOWLEDGEMENTS

This methodology was developed by Andes Ag, Inc., with important contributions from external reviewers.

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1| KEY INFORMATION

1.1.1 | The following table describes the key information for the application of methodology.

Table 1. Key information

Activity[1] summary	Activities that involve the application of a microbial inoculant intended to increase SIC in agricultural soils in existing cropland for CO_2 removal.
Type of GHG mitigation measure(s)	☒ Nature based carbon dioxide removal
Mitigation type	☒ Emission removals
Applicable activity scale	☒ Micro scale (e.g., ≤10,000 tCO_{2e} per year) ☒ Small scale (e.g., ≤60,000 tCO_{2e} per year) ☒ Large scale (e.g., >60,000 tCO_{2e} per year)
Sectoral Scope	15. Agriculture
Activity Requirement	Agriculture activity requirement
Activity start date	The earliest date of microbial application on the fields included within the project area.
Crediting Period start date	The start date of project activity (earliest microbial application date within the fields included in the project) or a maximum of three years prior to the date of project design certification, whichever occurs later.
Crediting period length	Project follows a five-year renewal cycle per latest version of GS4GG requirements for renewal of crediting period and can be renewed once. Total crediting period shall be Ten years (maximum); If any legal mandate comes into force during the crediting period, the mitigation activity can be credited only until the date the legal requirements take effect.
Geographical applicability	Global
Limitations	NA

[1] The terms 'Activity', 'Project' and 'Project Activity' refer to the activity certified by GS4GG and are used interchangeably

2| APPLICABILITY CRITERIA

2.1.1 | **Geographic location:** Projects are eligible in all countries.

2.1.2 | **Project Area Requirements**:

a. The project area shall be on existing cropland and include both treated and untreated areas, i.e., baseline areas. Baseline units are linked to treated units based on five criteria listed in Table 7 and are not necessarily in the same field.

b. All individual treated units and baseline units shall have an average pH equal to or higher than 6.3 at the early-season sample timepoint (Time 0).

c. Project area(s) shall not be on wetlands[2] or irrigated land.

d. The eligible area shall not meet the definition of forest within the 10 years prior to the project start date. If the eligible area has been deforested during the last 10 years prior to the project start date, the project activity eligibility shall be determined by Gold Standard as part of the preliminary review. The project developer shall provide evidence that the deforestation activity has not taken place with an intention to implement project activities that generate any kind of certificate or carbon revenue or other similar certification-based revenue.

2.1.3 | **Site preparation and land use:**

a. Treated units within the project area shall apply a microbial inoculant once per growing season at the time of planting. The project developer is responsible for determining the optimal application rates based on lab studies, field trials, and/or peer-reviewed scientific research. Untreated baseline units are exempted from this condition.

b. Agricultural limestone or other carbonate materials shall not be applied to treated units or baseline units in the 12 months prior to microbial inoculant application or during the growing season when the microbial inoculant is applied.

i. The project activity shall not lead to land use change.[3]

ii. Managed cropping systems (e.g., single crop or crop rotation) shall have been in place for at least five years before project implementation (fallowing is acceptable).

iii. The application of this methodology shall not involve any change in field management practices that could lead to increased

[2] 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 /.

[3] For activities involving land use change from grassland to cropland and vice-versa, project developers shall contact the Gold Standard Secretariat for guidance.

greenhouse gas (GHG) emissions (e.g., increased synthetic fertiliser application, deeper tilling, increased manure application, crop residue burning).

iv. Changes in management practices that enhance sustainability (e.g., adoption of cover crops, transition to no-till) are permitted during the project activity, provided these practices are implemented equally on the treated units and their corresponding baseline units. The application of the microbial inoculant must be the only significant variable differentiating the treated units from the baseline units.

2.1.4 | **Legal and Regulatory compliance:**

a. The project shall not undermine or conflict with any national, sub-national, or local regulations or guidance relevant to project activity.

a. The microbial inoculant shall be registered as a soil amendment, biofertiliser, bio stimulant, or a related category with the national or subnational agricultural department or similar entity that oversees the project location(s).

b. The microbial inoculant shall NOT have an adverse effect on human, animal, or plant health, on safety, or the environment under reasonably foreseeable conditions of storage or use. This may be demonstrated via compliance with any regulations in the approval/registration process of the microbial inoculant or compliance with similar national/ subnational regulations, e.g., Regulation (EU) 2019/1009.

c. The microbial inoculant shall not contain any GMO as part of its composition.

2.1.5 | **Credit/Payment Stacking and Double Issuance:**

a. No other SIC programs are allowed in the project area. Beyond that, there are no other restrictions on either payment or credit stacking under this methodology.

b. By the nature of the direct Calcium Carbonate Equivalent (CCE) measurement method described in Section 11|, it is compatible with regenerative agriculture carbon programs (SOC programs) in the same project area.

   i. To mitigate the risk of double issuance and claims, the project developer shall conform with the requirements and apply the procedures in the GHG Emissions Reduction & Sequestration Product Requirements.

2.1.6 | **Environment, ecology, and land use:** Activities applying this methodology shall adhere to the requirements in the Safeguarding Principles and Requirements. In particular, Principle 9, "Environment, Ecology, and Land Use," requires the project developer to ensure a precautionary approach to avoid negative environmental impacts.

2.1.7 | **Durability**:

a. With rainfall and acidity, the SIC built up in the soil will be transported down the soil profile. Eventually, the SIC will reach the water table and then long-lived reservoirs, including groundwater, rivers, and the ocean[4].
b. Once reaching the ocean, the durability is estimated to be on the order of 10,000 years or more[5,6,7].

2.1.8 | **Compliance buffer**: According to the GHG Emissions Reduction & Sequestration Product Requirements, for projects applying the Agriculture Activity Requirements, 20% of the issued GS-VERs shall be transferred into the Gold Standard buffer.

3| SOURCES AND REFERENCES

3.1.1 | This methodology refers to following methodologies, tools, and documents:
a. Agriculture Activity Requirements
b. Requirements for additionality demonstration.

4| DEFINITIONS

4.1.1 | The definitions outlined in the Glossary of Gold Standard for the Global Goals and the Agriculture Activity Requirements shall apply, in addition to those outlined below:

Table 2. Terms and definitions

TERM	DEFINITION
Agricultural land	Land dedicated to agricultural production, including arable land, permanent cropland, and permanent pastures.
Baseline area	Agricultural land used as a reference or control for the treated project area. The baseline area is the collection of all baseline units. This area should meet all applicability conditions except for the condition requiring the application of a microbial inoculant for increasing SIC (see Section 2|).

[4] Batool, M., Cihacek, L. J., & Alghamdi, R. S. (2024). Soil Inorganic Carbon Formation and the Sequestration of Secondary Carbonates in Global Carbon Pools: A Review. Soil Systems, 8(1), 15. https://doi.org/10.3390/soilsystems8010015
[5] Yoshiki Kanzaki, Noah J Planavsky, Christopher T Reinhard, New estimates of the storage permanence and ocean co-benefits of enhanced rock weathering, *PNAS Nexus*, Volume 2, Issue 4, April 2023, pgad059, https://doi.org/10.1093/pnasnexus/pgad059
[6] Raymond PA, Cole JJ. Increase in the export of alkalinity from North America's largest river. Science. 2003 Jul 4;301(5629):88-91. doi: 10.1126/science.1083788. PMID: 12843391. https://pubmed.ncbi.nlm.nih.gov/12843391/
[7] Kessler, Toby J., Harvey, Charles F., The global flux of carbon dioxide into groundwater, Geophysical Research Letters,28.2, 0094-8276, https://doi.org/10.1029/2000GL011505

Baseline unit (BU)	A field stratum with no microbial inoculant applied, serving as a reference or control to compare against treated units.
Baseline unit pool (BUP)	Baseline units from a monitoring period (e.g., the 2023 growing season) that are grouped together based on the similarity criteria (see Table 7).
Calcium carbonate equivalent (CCE)	The quantity of carbonate (CO_3^{2-}) in the soil expressed as $CaCO_3$ and as a weight percentage of the less than 2 mm soil size fraction of dried and sieved soil. CCE represents all inorganic carbon molecules, including carbonate and bicarbonate compounds as well as carbonate and bicarbonate ions.
Cation exchange capacity (CEC)	A measure of how many cations can be retained on soil particle surfaces. This influences the soil's ability to hold essential nutrients.
Crop	A plant such as a grain, fruit, or vegetable grown in large amounts.
Cropland	A land cover or land use that includes areas used to produce adapted crops for harvest. Before the start of the project, the ability of the microbial inoculant to fix CO_2 from the atmosphere with selected crop types should be demonstrated in lab and field studies. Project developers should select crop types that satisfy methodology requirements and are suitable for the project geography. It is important for the project developer to assess the time period for SIC generation to occur with the microbial inoculant of interest and select a crop with a life cycle greater than or equal to that time period.
Durable	The isolation of CO_2 from the atmosphere for at least 200 years. Note that this time frame may be reassessed in future versions.
Existing cropland	Land that functioned predominantly as cropland for the majority of the five years prior to the project's start date, serving as a reference point for evaluating project applicability.
Farm operator	A person who runs a farm, making day-to-day management decisions. This could be an owner, hired manager, cash tenant, share tenant, and/or a partner, as defined by the U.S. Department of Agriculture (USDA) Economic Research Service glossary.[1]
Field strata (singular: stratum)	The distinct subgroups within a field that are created through the stratification process. A field stratum is considered to be a sample unit and is used for statistical analysis. Each field stratum is characterized by specific attributes or criteria. (See Section 15.3 for details.) A field stratum is either a baseline

	unit (i.e., if it is untreated) or a treated unit (i.e., if it is treated with the microbial inoculant).
Forest	A forest is defined by the Designated National Authority (DNA) of the project's host country (refer to cdm.unfccc.int/DNA/index.html or updated page under PACM). – In case no forest definition is provided by the DNA, the project developer can refer to the national forest definition of the project's host country. In case no forest definition is established by the host country, the project developer can refer to the forest definition provided by the Food and Agricultural Organization of the United Nations (FAO) Forest Resource Assessment 2020 - Terms and Definitions: "Land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use."
Genetically modified organism (GMO)	A living organism whose genetic material/DNA has been artificially altered using genetic engineering techniques. It also applies to incorporating foreign genes from other species into the genome of the microbial inoculant used in the fields.
Growing season	A period within a year during which growing conditions for crops are most favourable. The length of the growing season can vary significantly depending on geographical location, climate, and specific crop requirements.
Microbial inoculant	A specific microbe or group of microbes intentionally introduced into the soil to promote the generation of SIC on agricultural lands; these include bacteria, archaea, and fungi. The microbe(s) may be live or dormant, but if dormant, they shall leave the dormant state after reaching the ground.
Monitoring period	The length of time over which project activity is measured to quantify emissions removals. In the context of this methodology, the monitoring period is the growing season for the project area, and the sampling requirements are outlined in Section 15.3 |.
Project area	Agricultural land, some of which is subject to microbial inoculant application to generate SIC (i.e., treated units) and some of which is not (i.e., baseline units).
Sample unit	A defined area selected for measurement and monitoring, such as a specific section of a field. In the context of stratified random sampling, sample units refer to the field strata.

Sampling point	A predetermined location within a field or field stratum where soil samples are collected for analysis.
Soil bulk density	An indicator of soil compaction. It is calculated as the dry weight of soil divided by its volume. This volume includes the volume of soil particles and of pores among soil particles. Bulk density is typically expressed in g/cm^3.
Soil inorganic carbon (SIC)	The collective term for all inorganic carbon molecules in the soil, encompassing carbonate compounds, bicarbonate compounds, and carbonate and bicarbonate ions. SIC is commonly measured and quantified as CCE %, e.g., grams of $CaCO_3$ per 100 grams of soil and CCE % per hectare.
Soil organic carbon (SOC)	Synonymous with total organic carbon, referring to the carbon content stored within soil organic matter. SOC is typically expressed as SOC % (grams of organic carbon per 100 grams of soil).
Soil organic matter (SOM)	Materials originally produced by living organisms that are incorporated into soils and undergo decomposition and transformation. Examples include plant roots, exudates, microbes, and other organic residues. SOM is typically expressed as SOM % (grams of organic matter per 100 grams of soil).
Soil pH	An indication of the acidity or alkalinity of soil that is measured in pH units, using the soil: water suspension method. Soil pH is defined as the negative logarithm of the hydrogen ion concentration.
Soil spectroscopy	A technique used to analyse and measure the properties of soils by examining how they interact with light across different wavelengths. This method involves shining light (often visible, near-infrared, or mid-infrared) on a soil sample and measuring the reflected or transmitted light to determine various soil characteristics, such as organic matter content, moisture levels, mineral compositions, and texture.
Stratification	The process of dividing a larger area or population into distinct subgroups or strata based on specific criteria or variables. Stratification aims to create homogeneous subgroups that share similar attributes within themselves while exhibiting differences between the subgroups, facilitating more accurate analysis, sampling, and understanding of the underlying patterns or characteristics within the larger population or area.
Total carbon (TC)	The sum of both organic and inorganic carbon present in a given system or sample, e.g., TC % (grams of organic carbon and $CaCO_3$ per 100 grams of soil).

Total organic carbon (TOC)	The amount of carbon stored within SOM, derived from the decomposition and transformation of plant and animal residues, root exudates, living and deceased microorganisms, and soil biota. TOC is typically expressed as TOC % (grams of organic carbon per 100 grams of soil).
Treated unit (tu)	A field stratum treated with a microbial inoculant to sequester carbon in the form of SIC (measured as CCE).
Treated unit pool (tup)	All of the treated units from a monitoring period (e.g., the 2023 growing season) that are grouped together based on the similarity criteria (see Table 7).

5| ACTIVITY SCOPE AND BOUNDARY

5.1 | Activity scope

5.1.1 | This methodology is applicable to projects involving the application of a specific microbial inoculant intended to increase SIC in agricultural soils on existing cropland to result in durable CO_2 removal.

5.2 | Activity boundary

5.2.1 | The project boundary shall encompass all areas and sites directly involved in the project's activities:

a. Included Sites:

i. **Field site(s):** This includes agricultural land, specifically cropland, where the microbial inoculant is applied and where SIC is measured as CCE. Both treated units and baseline units are included in the project boundary. There is no maximum project area, provided all applicability conditions are met.

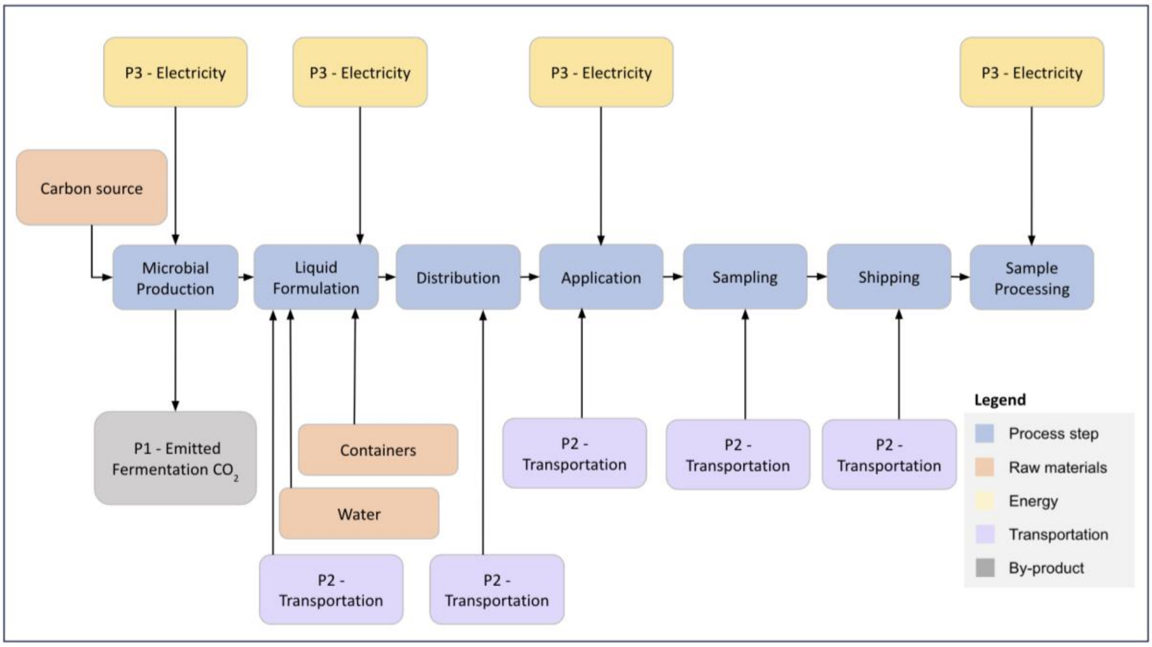
ii. **Non-field site(s):** This includes the location(s) where the microbial inoculant is produced, formulated into liquid, and where soil samples are analysed.

b. **Excluded Areas:** Regions without crops, e.g., sheds, fence-lines, and roads are not part of the project boundary.

c. **Boundary Identification:** The location of each field site shall be uniquely identified using global positioning system (GPS) coordinates.

5.2.2 | The project developer shall provide supporting documentation demonstrating the field site(s), such as shape files, aerial photographs, maps, or satellite imagery which clearly delineates the field sites

Figure 1: Project process flow diagram and baseline, project, leakage emissions sources and sinks



5.3 | Baseline emissions/removals

5.3.1 | Baseline emissions sinks considered for assessment are those related to SIC that would have been sequestered through the continuation of standard agricultural practices without the project. To represent this, baseline units are used to isolate the effect of the microbial inoculant. These units have soil types and conditions that are representative of the treated units, ensuring that the measured SIC generation is directly attributable to the project activity.

5.3.2 | The following table details the baseline emissions sinks included in, or excluded from, the activity scope:

Table 3. GHGs included in, or excluded from, the activity

SOURCE		GAS	INCLUDED	JUSTIFICATION
Baseline	B1: CO_2 drawdown that would have happened via a continuation of standard agricultural practices in the absence of the project	CO_2	Yes	Baseline CO_2 drawdown is determined based on the direct measurement of SIC on baseline units, which have representative soil types and conditions compared to treated sample units.
		CH_4	No	It is conservative to exclude non-CO_2 emissions in the baseline, as the primary GHG monitored (non-emission source) with all SIC project activities is CO_2.
		N_2O	No	Same as N_2O above

5.4 | Activity emissions/removal

5.4.1 | The following project emissions sinks and sources shall be considered for assessment:

a. Sinks:

i. SIC sequestered as a direct result of project activities.

5.4.2 | Loss of SOC attributable to project activities (if applicable).

a. Sources:

i. **Microbial Inoculant Lifecycle:** Emissions from the production, packaging, distribution, and field application of the inoculant.

ii. **Sampling and Analysis:** Emissions from soil sampling for both treated and baseline units (including associated transportation) and the subsequent processing of these samples.

5.4.3 | If there is evidence that the chosen microbial inoculant could produce a significant amount of nitrous oxide (N_2O), its emissions shall be included and monitored.

5.4.4 | The following table details the GHG emissions included in, or excluded from, the activity scenario(s):

Table 4. Emissions sources and sinks included in or excluded from the project boundary.

SOURCE	GAS	INCLUDED	JUSTIFICATION
Activity emissions: P1: Loss of Soil Organic Carbon (SOC)	CO_2	Included	Emissions resulting from the loss of SOC stocks attributable to the project activity (e.g., due to priming effect).
Activity emissions P2: Emitted fermentation CO_2	CO_2	Included	Emissions are attributed to the fermentation process used to produce the microbial inoculant. CO_2, methane (CH_4), and N_2O emissions are associated with these activities.
	N_2O	Included	Same as CO_2 above
	CH_4	Included	Same as CO_2 above
Activity emissions P3: Emissions from transportation related to the liquid formulation, distribution, and application of the microbial inoculant	CO_2	Included	Emissions are attributed to the fossil fuel consumption for transportation of the microbial inoculant and transportation related to soil sample collection and shipping. CO_2, CH_4, and N_2O emissions are associated with these activities.

and related to soil sampling and shipping. Transportation may generally be by freight truck and by car.	N_2O	Included	Same as CO_2 above
	CH_4	Included	Same as CO_2 above
Activity emissions P4: Emissions from electricity usage during microbial production, liquid formulation, application, and sample processing	CO_2	Included	Emissions are attributed to fossil fuel consumption for electricity usage. CO_2, CH_4, and N_2O emissions are associated with these activities, depending on the energy mix of the electric grid.
	N_2O	Included	Same as CO_2 above
	CH_4	Included	Same as CO_2 above

5.5 | Leakage emissions

5.5.1 | The following table details the GHG emissions included in, or excluded from, the leakage scenario:

Table 5. GHGs included in, or excluded from, the leakage scenario(s)

SOURCE	GAS	INCLUDED	JUSTIFICATION
Leakage	CO_2	Included	Any CO_2 emissions attributed to leakage are to be considered.
	N_2O	Included	Same as above
	CH_4	Included	Same as above

6| DEMONSTRATION OF ADDITIONALITY

6.1 | Requirements

6.1.1 | Additionality shall be demonstrated in accordance with the prescribed methods in the GS4GG Requirements for Additionality Demonstration. Project developers shall ensure the activity meets the criteria through the following analyses, noting where assessments have been conducted at the methodology level:

Analysis type	Level of assessment
A regulatory analysis	Conducted at the activity level

A lock-in analysis	Conducted at the methodology level; see Annex 01
A financial additionality assessment	Conducted at activity level, Investment or Barrier analysis, unless Option 1 applies
A common practice analysis	Conducted at the methodology level; see Annex 02

6.1.2 | The proposed project activity shall only be considered additional if all four analyses are concluded positively.

6.2 | Regulatory analysis

6.2.1 | The project activity shall comply with the following regulatory requirements:

6.2.2 | **Host Country Eligibility:** The project activity type shall not be excluded or declared ineligible by the host country (e.g., via a negative list of activities, technologies, or measures for the issuance of carbon credits). If no such list is available from the host country, the activity shall be assumed as not excluded or declared ineligible.

6.2.3 | **Legal Mandates:** The project activity shall not be mandated by any existing or pending law, statute, regulation, standard, or legal requirement within the host Party's jurisdiction. An exception is permitted if the law or regulation explicitly refers to or formally integrates Article 6 based mechanisms as an instrument for implementation. Evidence shall be provided demonstrating that there is no legal obligation to apply microbial inoculant or implement similar technology/measure to enhance soil inorganic carbon.

6.2.4 | GS-VERs cannot be claimed for emission reductions that result from meeting the legal requirement(s). However, GS-VERs for emission removals achieved by exceeding the regulatory requirements may be claimed.

6.2.5 | The assessment shall be conducted at start of 1st crediting period and for each monitoring period.

6.3 | Avoidance of locking-in the level of emissions

6.3.1 | The Project activities meeting the applicability conditions of this methodology shall not lead to locking-in emissions levels or carbon emissions-intensive practices (e.g., by prolonging the lifetime of emissions-intensive technologies or through new installations using such technologies).

6.3.2 | As justified in Annex 01, the lock-in risk analysis has been conducted at the methodology level. This analysis concludes that the short operational lifetime of the practice (one year) presents no risk of lock-in. Therefore, a lock-in risk analysis is not required at the activity level. Activity developers shall ensure ongoing compliance with the methodology's applicability criteria, which inherently mitigates potential lock-in risks.

6.4 | Common practice analysis – Methodology level

6.4.1 | The analysis in Annex 02 concludes that this technology/measure is not common practice (Common Practice Factor F=0%). Therefore, projects that meet the applicability conditions of this methodology are considered to have satisfied the common practice test and are not required to conduct a project-level common practice analysis.

6.5 | Financial additionality

6.5.1 | The project developer shall demonstrate that

a. the proposed project activity is not financially viable or faces significant barriers without carbon credit revenue.

b. the carbon credit revenue decisively improves the financial viability or helps overcome the barriers, making the activity viable.

6.5.2 | The assessment shall follow one of the following options, summarized in Table, below.

Table 6. Options for financial additionality demonstration

Project Scale	Required Analysis	Key Requirements
All scales with no other revenue streams	Deemed additional at methodology level	Justified by the F = 0% Common Practice Analysis findings. No project-level financial analysis is required.
Large scale with other revenues	Investment Analysis	Conduct a comparative financial analysis (e.g., NPV, IRR). Demonstrate the project becomes the most financially attractive option only with carbon credits.
Small or micro scale with other revenues	Investment Analysis or	As above
	Barrier analysis	Demonstrate that carbon revenue is the determining difference in overcoming at least one significant barrier, considering all other revenue streams.

Option 1 – Methodology level assessment

6.5.3 | For project activities that have no other revenue streams[8] beyond carbon credits, the financial additionality requirement is deemed satisfied at the

[8] **Definition of Revenue Streams:** For the purposes of this methodology, "other revenue streams" (utilized in Table 6 and Option 1) refers exclusively to financial benefits directly resulting from the implementation of the project activity (i.e., the application of the microbial inoculant), excluding revenue from the sale of carbon credits. This does not include baseline agricultural revenue (e.g., standard crop sales). Examples of "other revenue streams" may

methodology level. The finding from the Common Practice Analysis (Annex 02, F=0%) serves as verifiable justification that the activity is not an autonomous market practice and would not have occurred without carbon revenue.

6.5.4 | The option 1 is valid for three years from publication date of version of 1 of this methodology.

Option 2 – Activity level assessment

6.5.5 | When alternative and/or additional revenue streams are available, activity-level analysis is required to demonstrate investment or barrier additionality.

6.5.6 | **Investment Analysis (if used):** Conduct a comparative financial analysis (e.g., Net Present Value (NPV), Internal Rate of Return (IRR) of the project activity versus the baseline scenario. Demonstrate that the project activity, without carbon revenues, is economically less favorable than the baseline, and that with carbon revenues, the activity becomes the most financially attractive scenario. The analysis shall use realistic, documented, and conservative assumptions for costs, discount rates, etc. Sensitivity analysis shall be performed on key parameters.

6.5.7 | **Barrier analysis:** Barrier analysis may be applied for microscale and small-scale activities with or without a financial viability analysis. For large-scale activities, it may be applied in combination with financial viability analysis. Project developers shall demonstrate that implementation of proposed project activity would be prevented by specific barriers (such as institutional, information or financial barriers) and that carbon credit revenue makes the determining difference in overcoming them.

6.6 | Common practice analysis – Activity level

6.6.1 | The methodology exempts the project level common practice analysis. Refer to Annex 02 for further details.

7| BASELINE SCENARIO

7.1 | Selection of baseline approaches

7.1.1 | In accordance with GS4GG methodological standard - "Requirements for Methodology Development", this methodology utilizes approach (c), based on existing actual or historical emissions/removals, adjusted downwards.

7.2 | Justification for the Baseline approach

7.2.1 | The selection of this approach is justified as the most appropriate for this methodology for the following reasons:

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include significant, documented yield increases or input cost reductions directly attributable to the inoculant.

7.2.2 | **Appropriateness to Activity Context:** The project activity involves the application of microbial inoculants to enhance CO_2 removal via the formation of soil inorganic carbon (SIC). SIC dynamics are highly site-specific and dependent on complex interactions between crop type, soil properties (e.g., pH, minerology), climate conditions, and prevailing management practices. A universal benchmark (approach b) or BAT approach (approach a) cannot adequately capture these localized variations.

7.2.3 | **Use of Best Available Data and Accuracy:** The methodology mandates a dynamic, directly measured baseline. SIC changes are measured in untreated baseline units (control plots) maintained concurrently with the treated units. This ensures the baseline is grounded in robust, verifiable, site-specific data, providing the most accurate assessment of the counterfactual scenario (what would occur in the absence of the activity).

7.2.4 | **Conservativeness:** Using actual measured SIC changes from concurrent control plots ensures that only the incremental removals attributable to the microbial inoculant are credited, avoiding the risk of overestimation.

7.3 | Identification of the Baseline scenario

7.3.1 | The baseline scenario represents the most likely scenario that would occur in the absence of the project activity. The project developer shall determine the baseline scenario using the following stepwise approach:

Step 1 – Identification of Baseline geographical reference area:

7.3.2 | The baseline geographical reference area is the host country by default.

7.3.3 | The activity developer may limit the reference area to a narrower specific geographical area (e.g., subnational region, state) within the host country if it can be demonstrated that significant differences exist between the specified area and the remainder of the host country (e.g., unique climatic conditions, soil compositions, or agricultural practices).

Step 2 – Identification of Plausible Alternative Scenarios

7.3.4 | The activity developer shall identify all plausible alternative technologies and/or practices available within the baseline geographical reference area that can deliver the same outcome—specifically, the enhancement of SIC in agricultural soils. This includes, but is not limited to:

7.3.5 | The continuation of prevailing agricultural practices without the application of a microbial inoculant for SIC enhancement.

7.3.6 | The application of other technologies or soil amendments (e.g., enhanced weathering) intended to increase SIC, if available in the reference area.

7.3.7 | Adoption of different microbial inoculants available in the market intended to increase SIC.

Step 3 - Identification of the representative baseline scenario

7.3.8 | The activity developer shall determine which alternative identified in Step 2 above, represents the most likely baseline scenario, considering barriers to implementation, economic attractiveness, and common practices.

7.3.9 | Based on the methodology-level Common Practice Analysis (see Annex 02), the application of technologies specifically for SIC enhancement is not practiced autonomously (F=0%). Furthermore, the Additionality demonstration confirms that the project activity is not financially viable without carbon revenues. Therefore, the continuation of prevailing agricultural practices is the most economically attractive option in the absence of the project.

7.3.10 | The representative baseline scenario is the continuation of prevailing agricultural practices without the application of a microbial inoculant for increasing SIC.

7.4 | Operationalizing the Baseline Scenario (Control Plots)

7.4.1 | To accurately quantify the removals attributable to the project activity, this methodology uses untreated sample locations (i.e., baseline units) to measure the baseline scenario.

7.4.2 | **Baseline Units as Controls:** The Untreated sample locations (i.e., baseline units) serve as dynamic controls, isolating the effect of the microbial inoculant treatment. These units shall meet all applicability conditions of the methodology, except for the application of the microbial inoculant.

7.4.3 | **Representativeness and Linking:** Baseline units shall be representative of the treated units. The baseline units are pooled and linked based on the key similarity criteria defined in Table 7. To ensure a valid comparison between treated and baseline units, SIC generation on treated units throughout the growing season shall be compared to SIC generation on the baseline units throughout the same growing season.

7.4.4 | **Consistency of Management:** The project developer must ensure and document that all field management practices (e.g., fertilization, tillage, cover cropping, pest management) other than the microbial inoculant application are consistent between the treated units and their linked baseline units during the monitoring period. Any changes in management adopted during the project must be applied equally to both treated and baseline units.

7.4.5 | For projects using this methodology, area covered by the baseline units shall represent at least 5% of the total project area. These baseline units shall be required for each stratum.

Table 7. Similarity criteria for pooling and linking the baseline and the treated unit.

Similarity Criteria	Description	Groups/Classes (Examples)

Soil group	Units shall be within the same reference soil group, according to the World Reference Base for Soil Resources (WRB).	Acrisols, Alisols, Andosols, Anthrosols, Arenosols, Calcisols, Cambisols, Chernozems, Cryosols, Durisols, Ferralsols, Fluvisols, Gleysols, Gypsisols, Histosols, Kastanozems, Leptosols, Lixisols, Luvisols, Nitisols, Phaeozems, Planosols, Plinthosols, Podzols, Solonchaks, Solonetz, Stagnosols, Technosols, Umbrisols, Vertisols
Climate zone	Units shall be within the same climate zone, according to the Köppen-Geiger climate classification.	Af, Am, As, Aw, BSh, BSk, BWh, BWk, Cfa, Cfb, Cfc, Csa, Csb, Csc, Cwa, Cwb, Cwc, Dfa, Dfb, Dfc, Dfd, Dsa, Dsb, Dsc, Dsd, Dwa, Dwb, Dwc, Dwd, EF, ET
Crop type	Units shall share the same crop type as the linked treated units (e.g., soybean).	Soybean, corn, wheat, canola, sunflower, cotton, sorghum, flax, other crops
Soil Texture Class	Units shall be within the same soil textural class according to a standardized classification system (e.g., USDA Soil Taxonomy or FAO).	Sandy Loam, Silt Loam, Clay Loam, Clay, etc.
Tillage Regime	Units shall employ the same primary tillage management system during the monitoring period.	Conventional Tillage, Reduced/Conservation Tillage, No-Till/Zero Tillage.

8| CALCULATION OF BASELINE REMOVALS

8.1 | Baseline Removals

8.1.1 | Baseline removals are the changes in SIC and SOC stocks that would have occurred in the absence of the project activity during the monitoring period *y*. These are determined through direct measurement of SIC (as CCE) and SOC in the baseline units.

8.1.2 | This methodology uses a paired-plot approach where baseline removals are not calculated in isolation. Instead, the calculation of Activity Removals (ARy) inherently accounts for baseline removals. The measured change in CCE in the baseline unit pools ($\Delta CCE_{bup,y}$ see Equation 29) is subtracted from the change in CCE in the corresponding treated unit pools to determine the additional CCE generated by the project activity. Changes in SOC are assessed in parallel and any SOC losses relative to baseline attributable to the project activity are deducted; positive SOC changes do not generate credited removals.

8.2 | Baseline Emissions (BE_y)

8.2.1 | The applicability criteria of this methodology require that the only eligible change in field management practices is the application of the microbial inoculant. The methodology prohibits changes that alter GHG emissions (e.g., changes in fertilizer application or tillage). Since the project activity does not replace or modify the emission-causing practices of the baseline scenario, the emissions from standard agricultural operations (e.g., fossil fuel use, N_2O from fertilization) are considered equivalent in both the baseline and project scenarios.

8.2.2 | The baseline GHG emissions in monitoring period *y* (BE_y) are considered zero:

$$\boldsymbol{BE_y = 0} \qquad (eq.\ 1)$$

Where:

BE_y	=	Baseline GHG emissions during the monitoring period y due to the activity (tCO_2)

Note: Emissions associated with the monitoring of the baseline units (e.g., transportation for soil sampling and sample processing) are attributable to the project and are therefore accounted for under AE_y).

8.3 | Difference between BAU and baseline emissions or removals

8.3.1 | For this methodology, the baseline scenario is the same as the Business-as-Usual (BAU) scenario. Therefore, the baseline emissions are equal to the BAU emissions, and no difference needs to be estimated.

8.4 | Application of downward adjustment

8.4.1 | Refer to Section 12 Calculations of NET GHGs removals.

9| ACTIVITY SCENARIO

9.1 | Identification of Activity Emission Sources

9.1.1 | Activity emissions (AE_y) are all GHG emissions occurring within the project boundary during the monitoring period *y* that are attributable to the project activity. The spatial extent of the project boundary includes field sites and non-field sites (production, formulation, and analysis locations), as defined in Section 5.2.

9.1.2 | The following emission sources shall be included, as summarized in Table 2 and illustrated in the process flow diagram (Figure 1)

a. **P1: Fermentation Emissions:** Direct emissions (CO_2, CH_4, N_2O) resulting from the fermentation process during microbial production.
b. **P2: Transportation Emissions:** Emissions from fossil fuel consumption related to the transport of raw materials, distribution of the inoculant, and transportation for soil sampling and shipping.
c. **P3: Energy Use Emissions:** Emissions from electricity and/or fossil fuel consumption during microbial production, liquid formulation, field application, and sample processing/analysis.
d. **Embodied Emissions:** Emissions associated with the production and sourcing of raw materials (e.g., carbon source for microbial growth) and consumables (e.g., containers/packaging)

9.1.3 | **N_2O Emissions:** If there is peer-reviewed scientific evidence or manufacturer data indicating that the specific microbial inoculant used could produce a significant amount of nitrous oxide (N_2O) upon application to the soil, these emissions shall also be included and monitored.

9.2 | Calculation of total activity emissions

9.2.1 | Project developers shall calculate the total activity emissions ($\mathrm{AE_y}$) using one of the following two options. The chosen option shall account for all emission sources identified in Section 9.1.

a. Option 1: Life Cycle Assessment (LCA) Approach (Preferred)
b. Option 2: Component-Based Calculation Approach

9.2.2 | Option 1 (LCA) is preferred as it provides a comprehensive and standardized method for accounting for all upstream, operational, and embodied emissions.

Option 1: Life Cycle Assessment (LCA) Approach

Option 1a: LCA based on Area Treated

9.2.3 | Total activity emissions from the project in the monitoring period y (AE_y) are determined by applying an LCA factor to the total area treated

$$\boldsymbol{AE_y = Area_{treated,y} \times EF_{LCA,y}} \qquad (eq.\ 2)$$

Where:

AE_y	=	Total emissions in the monitoring period (tonnes of CO_2e)
$Area_{treated,y}$	=	Total area of treated units in the project during monitoring period y (ha)
$EF_{LCA,y}$	=	Life Cycle Assessment emission factor per hectare treated (tCO_2e/ha)

Option 1b: LCA based on Quantity of Microbial Inoculant

9.2.4 | Total activity emissions from the project in the monitoring period y (AE_y) are determined by applying an LCA factor the total quantity of microbial inoculant applied :

$$AE_y = Q_{inoculant,y} \times EF_{LCA,unit} \qquad (eq.\ 3)$$

Where:

$Q_{inoculant,y}$	=	Total quantity (mass or volume) of microbial inoculant applied during monitoring period y (e.g., kg or Liters)
$EF_{LCA,unit}$	=	LCA emission factor per unit of inoculant (e.g., tCO_2e/kg or tCO_2e/Liter)

9.2.5 | The LCA shall be conducted in accordance with ISO 14044 or a similarly rigorous accounting standard. The following requirements apply:

a. **Functional Unit:** The LCA shall clearly define the functional unit (e.g., treatment of 1 hectare, or application of 1 kg/Liter of inoculant).
b. **Scope and Boundary:** The LCA shall include all Sources, Sinks, and Reservoirs (SSRs) identified in Section 9.1 (P1, P2, P3, P4 and Embodied Emissions). The system boundary shall align with the project boundary defined in Section 5.2.
c. **Execution and Review:** The LCA can be performed by the producer of the microbial inoculant, the project developer, or a third party. If performed internally i.e., one of the producers of the microbial inoculant or the project developer, the LCA shall undergo an independent third-party review by a qualified expert to verify compliance with the referenced standard and this methodology.
d. **Data Quality and Validity**:
   i. The LCA shall utilize data representative of the actual processes used in the monitoring period.
   ii. The LCA study shall be updated at least every three years. The data utilized within the LCA for calculating AE_y shall be representative of the monitoring period y.
   iii. If an LCA component has a minimal contribution to total emissions (e.g., less than 5%), an assessment may be conducted once and fixed for five years at the project level, provided the underlying process remains unchanged and justification is documented.

Option 2: Component-Based Calculation Approach

9.2.6 | The activity emissions in the monitoring period y (AE_y) shall be determined by considering the emissions from process operations, transport activities, and embodied emissions. AE_y shall be calculated as follows:

$$AE_y = AE_{op,y} + AE_{tr,y} + AE_{em,y} \qquad (eq.\ 4)$$

Where:

AE_y	=	Total Activity emissions in monitoring period y (tCO_2)
$AE_{op,y}$	=	Activity emissions from process operations in monitoring period y (tCO_2)
$AE_{tr,y}$	=	Activity emissions from transport activities in monitoring period y (tCO_2)
$AE_{em,y}$	=	Embodied activity emissions (e.g., raw materials, packaging) in monitoring period y (tCO_2)

9.3 | Emissions from process operations ($AE_{op,y}$)

9.3.1 | Activity emissions ($AE_{op,y}$) includes emissions This includes emissions from electricity consumption, fossil fuel combustion, and direct emissions from processes (e.g., fermentation) during production, formulation, application, and analysis. and shall be calculated as follows:

$$\boldsymbol{AE_{op,y} = AE_{op,elec,y} + AE_{op,fuel,y} + AE_{process,y}} \quad (eq.\ 5)$$

Where:

$AE_{op,elec,y}$	=	Activity emissions associated with electricity consumption for process operations in monitoring period y (tCO_2e). Calculate according to the latest version of the CDM Tool to calculate baseline, project and/or leakage emissions from electricity consumption (or equivalent GS4GG/PACM tool when available).
$AE_{op,fuel,y}$	=	Activity emissions associated with fuel consumption for process operations in monitoring period y (tCO_2e). Calculate according to the latest version of the Gold Standard Methodological Tool 01: Project or Leakage Emissions from Fossil Fuel Combustion.
$AE_{process,y}$	=	Calculate P1 emissions based on monitored data regarding the volume of GHGs produced during fermentation, using stoichiometry or mass balance.

9.4 | Emissions from transport activities ($AE_{tr,y}$)

9.4.1 | This includes all P2 emissions related to the transport of materials, distribution of the inoculant, and transport for soil sampling and shipping.

9.4.2 | For each parameter associated with transportation, emissions shall be calculated according to Gold Standard Methodological Tool 02: Project or Leakage Emissions from Transportation.

9.5 | Embodied Emissions ($AE_{em,y}$)

9.5.1 | Emissions associated with the production of raw materials (e.g., carbon source) and consumables (e.g., packaging) shall be calculated using appropriate, conservative emission factors derived from reputable databases (e.g., Ecoinvent), peer-reviewed literature, or supplier-specific data. All data sources and assumptions shall be transparently documented.

10| LEAKAGE EMISSIONS

10.1 | Identification of leakage emission sources

10.1.1 | Leakage is defined as changes in anthropogenic emissions and/or removals of GHGs that occur outside the activity boundary and that are attributable to the activity. Potential sources of leakage for this methodology have been assessed, considering the following categories:

a. **Activity Shifting:** If the project activity leads to a significant reduction in agricultural productivity (crop yields) within the project area, agricultural production may be displaced to areas outside the boundary to compensate for the lost output. This displacement could potentially lead to increased GHG emissions (e.g., through land-use change or intensification). This is considered the primary potential source of leakage for this methodology. Procedures for monitoring and mitigating this risk are detailed in Section 10.3, Part A.

b. **Input Substitution:** Leakage may occur if the project activity leads to a significant increase in the use of external inputs sourced from outside the project boundary (e.g., importation of manure or other organic amendments) to maintain soil fertility or productivity, where such increases are attributable to the project activity. The GHG emissions associated with the sourcing, transport, and application of these inputs shall be accounted for as leakage. Procedures for monitoring and mitigating this risk are detailed in Section 10.3, Part B.

c. **Market Effects:** Market leakage occurs if the project activity significantly affects the supply or demand of agricultural products, leading to changes in production patterns and associated GHG emissions elsewhere. The project activity aims to maintain or enhance agricultural productivity (see Section 10.2) and does not restrict the supply of agricultural outputs. Therefore, significant market effects are highly unlikely, and leakage from this source is excluded

d. **Competition for resource uses:** Leakage could occur if the project diverts critical resources (e.g., water, energy, raw materials) from other uses, causing emissions-intensive alternatives to be adopted outside the boundary. The methodology includes applicability conditions to minimize competition for resources. It is explicitly not applicable to irrigated land, avoiding competition for water resources. It also prohibits changes in field management practices that could lead to increased GHG emissions (e.g., increased synthetic fertiliser application). Emissions related to the resources used to produce the microbial inoculant (e.g., energy, water, raw materials) are accounted for within the project boundary as Activity Emissions via LCA. Therefore, leakage from competition for resource uses is not expected and is excluded.

e. **Transfer of Baseline equipment or Practices:** Leakage may occur if equipment or practices used in the baseline scenario are transferred outside the project boundary, leading to increased emissions. The project activity involves the application of a microbial inoculant to existing cropland and does not involve the replacement or transfer of agricultural equipment used in the baseline scenario. Therefore, leakage from baseline equipment transfer is not expected and excluded.

10.2 | Avoidance or minimization of leakage

10.2.1 | The methodology is designed to avoid leakage by requiring that projects shall be set up to maintain or increase agricultural productivity. The project activity shall not lead to a systematic decrease in crop yields.

a. **Economic Incentives:** The project area is actively maintained for crop production throughout the crediting period. Crop producers rely on crop harvests for income and are generally risk-averse, making it unlikely that they would intentionally adopt or continue practices that reduce crop yields.

b. **Monitoring and Mitigation:** The methodology mandates rigorous monitoring of crop yields and includes procedures to address any observed reductions (see Section 10.3).

10.3 | Monitoring and Calculation of Leakage Emissions (LEy)

10.3.1 | To monitor and mitigate the risk of leakage identified in Section 10.1, the following procedures shall be applied during each monitoring period y.

10.3.2 | Total Leakage Emissions (LE_y) are the sum of leakage due to Activity Shifting ($LE_{AS,y}$) and leakage due to Input Substitution ($LE_{IS,y}$).

$$\boldsymbol{LE_y = LE_{AS,y} + LE_{IS,y}} \qquad \textit{(eq. 6)}$$

Where:

LE_y	=	Total Leakage Emissions during the monitoring period y (tCO_2e)
$LE_{AS,y}$	=	Leakage emissions due to Activity Shifting (tCO_2e)
$LE_{IS,y}$	=	Leakage emissions due to Input Substitution (tCO_2e)

Part A: Leakage due to Activity Shifting ($LE_{AS,y}$)

10.3.3 | This methodology employs a discounting approach for Activity Shifting: if productivity decreases significantly due to the project activity, the emission removals from the affected areas are discounted entirely.

Step A.1: Monitoring Yield Changes

10.3.4 | The project developer shall implement a system to monitor crop yields across the project area. If a reduction in yield on a specific field (or group of fields) is reported by the farm operator or identified through monitoring data, the project developer shall initiate an assessment.

Step A.2: Assessing Causality

10.3.5 | The project developer shall assess whether the yield reduction is attributable to the project activity. If the developer can demonstrate, with verifiable evidence, that the yield reduction is caused by factors unrelated to the project activity (e.g., documented extreme weather events, pest outbreaks, or regional yield reductions affecting both project and non-project areas), then no leakage is assumed for that field. If causality cannot be demonstrated as unrelated to the project activity, proceed to Step A.3.

Step A.3: Quantifying Yield Decline (Materiality Threshold)

10.3.6 | The project developer shall quantify the magnitude of the yield decline for the affected field(s). A materiality threshold of 5% is established; a decline greater than 5% is considered significant.

10.3.7 | The project developer shall demonstrate that the yield has not declined by more than 5% by applying one of the following approaches for the reported field(s):

Option 1: Comparison with Historical Yield

10.3.8 | Compare the yield during the monitoring period ($Y_{pp,c}$) on the affected field(s) to the average yield on the same field(s) during the five years immediately prior to the monitoring period ($Y_{hp,c}$). Years with documented extreme weather events may be excluded from the historical average calculation if justified.:

$$\Delta Y_{p,c} = \left(\frac{Y_{pp,c} - Y_{hp,c}}{Y_{hp,c}}\right) \times 100 \qquad (eq.\ 7)$$

Where:

$\Delta Y_{p,c}$	=	Change in yield for crop c per hectare (%)
$Y_{pp,c}$	=	Average yield for crop c on the reported field during the monitoring period in which the yield decrease is reported (tonnes of grain or biomass per hectare)

$Y_{hp,c}$	=	Average yield for crop c on the reported field during the five years before the monitoring period in which the yield decrease is reported (tonnes of grain or biomass per hectare)
c	=	Crop

Option 2: Comparison with Regional Yield Ratio

10.3.9 | Compare the ratio of the field yield to the average regional yield during the monitoring period, against the ratio of the historical field yield to the average regional yield during the five years prior. This approach helps normalize for inter-annual variability in climate.

10.3.10 | Average regional yield data shall be sourced from reputable government statistics (e.g., USDA Actual Production History data), industry reports, academic studies, or international organizations (e.g., FAO).

$$\boldsymbol{\Delta YR_c} = \left(\frac{\boldsymbol{Y_{pp,c}}}{\boldsymbol{RY_{pp,c}}} - \frac{\boldsymbol{Y_{hp,c}}}{\boldsymbol{RY_{hp,c}}}\right) \times \mathbf{100} \qquad \textit{(eq. 8)}$$

Where:

ΔYR_c	=	Change in yield ratio per hectare for crop c (%)
$Y_{pp,c}$	=	Average yield for crop c on the reported field during the monitoring period in which the yield decrease is reported (tonnes of grain or biomass per hectare)
$RY_{pp,c}$	=	Average regional yield for crop c during the monitoring period (in which the yield decrease is reported) (tonnes of grain or biomass per hectare)
$Y_{hp,c}$	=	Average yield for crop c on the reported field during the five years before the monitoring period in which the yield decrease is reported (tonnes of grain or biomass per hectare)
$RY_{hp,c}$	=	Average regional yield for crop c during the five years before the monitoring period in which the yield decrease is reported (tonnes of grain or biomass per hectare)
c	=	Crop

Step A.4: Addressal of Leakage (Activity Shifting)

10.3.11 | The addressal of leakage is determined based on the results of Step 3, above:

a. Yield Decline ≤ 5%: If the yield has improved, remained constant, or declined by 5% or less (i.e., $\Delta Yp,c$ or ΔYRc ≥ -5%), no leakage is assumed for the affected field(s).

b. Yield Decline > 5%: If a reduction of yield greater than 5% is observed (i.e., $\Delta Yp,c$ or ΔYRc < -5%), and it cannot be demonstrated (per Step 2) that the reduction is unrelated to the project activity, 100% of the emissions removals associated with the affected field(s) shall be accounted for as leakage.

10.3.12 | Procedure for Accounting (Activity Shifting): To ensure that no emissions removal credits are issued for field(s) where significant leakage has occurred, the project developer shall remove the affected field(s) from the relevant treated unit pool(s) before calculating the gross activity removals (ARy) for the project (i.e., before executing the calculations in Section 11.4).because the leakage is addressed by adjusting the Activity Removals (AR_y), the explicit calculation of $LE_{AS,y}$ in the Total Leakage Emissions equation is zero.

$$\boldsymbol{LE_{AS,y} = 0} \qquad \text{(eq. 9)}$$

Part B: Leakage due to Input Substitution ($LE_{IS,y}$)

Step B.1: Monitoring Input Changes

10.3.13 | The project developer shall monitor and document the use of external inputs—defined as materials sourced from outside the project boundary, such as manure, compost, or other organic amendments—on project fields annually via farm operator records. (Note: Increases in synthetic fertilizer use are restricted by the Applicability Criteria, Section 2).

Step B.2: Assessing Materiality and Causality

10.3.14 | The project developer shall compare the annual quantity of external inputs used during the monitoring period ($Input_y$) with the historical average quantity used during the five years prior to the project start date $Input_{hist}$)).

10.3.15 | A materiality threshold of 10% increase is established. If $Input_y$> 1.10 x $Input_{hist}$, the project developer shall assess if this increase is attributable to the project activity (e.g., implemented to compensate for changes in soil fertility related to the project).

10.3.16 | If the increase is demonstrated to be unrelated to the project activity (e.g., part of a documented regional shift in practices, response to unrelated soil deficiencies), no leakage is assumed. If the increase is attributable to the project activity, proceed to Step B3.

Step B.3: Quantifying Input Substitution Emissions

10.3.17 | If a material increase in inputs is attributable to the project, the GHG emissions associated with the sourcing, transport, and application (including N_2O and CH_4 emissions from application) of the incremental inputs shall be calculated.

$$\boldsymbol{Input_{incremental} = Input_y - Input_{hist}} \qquad \text{(eq. 10)}$$

$$LE_{IS,y} = \sum_i \left(Input_{incremental,i,y} \times \left(EF_{sourcing,i} + EF_{transport,i} + EF_{application,i} \right) \right) \quad (eq.\ 11)$$

Where:

$Input_{incremental,i,y}$	=	Incremental quantity of input type i used in monitoring period y attributable to the project (tonnes)
$EF_{sourcing,i}$	=	Emission factor for sourcing input type i (tCO_2e/tonne).
$EF_{transport,i}$	=	Emission factor for transport of input type i (tCO_2e/tonne).
$EF_{application,i}$	=	Emission factor for field application of input type i, including N_2O/CH_4 (tCO_2e/tonne).
$LE_{IS,y}$	=	Leakage emissions due to Input Substitution (tCO_2e)

10.3.18 | Emission factors shall be derived from reputable databases, peer-reviewed literature, IPCC guidelines (e.g., 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4), or relevant approved methodological tools. Transport emissions shall be calculated according to the Gold Standard Methodological Tool 02: Project or Leakage Emissions from Transportation.

10.3.19 | If no significant increase attributable to the project is observed.

$$LE_{IS,y} = 0. \quad (eq.\ 12)$$

11| ACTIVITY REMOVALS

11.1 | Mechanism of Removal

11.1.1 | The project activity removes atmospheric CO_2 and durably stores it by applying a microbial inoculant to existing cropland. This approach leverages the mutualistic relationship of beneficial soil bacteria and plant roots to capture CO_2 (which originates from the atmosphere via plant photosynthesis and subsequent root/soil respiration) and convert it into SIC.

11.1.2 | The primary emissions sink is the SIC that is sequestered as direct result of project activities. The forms of SIC generated by the project are carbonate minerals, bicarbonate and carbonate ions, and bicarbonate and carbonate salts (e.g., $CaCO_3$, $CaMg(CO_3)_2$, HCO_3^-, CO_3^{2-}, $Ca(HCO_3)_2$, $NaHCO_3$, Na_2CO_3).

11.2 | Quantification Approach

11.2.1 | Emissions removals attributable to the application of the microbial inoculant (AR_y) are calculated as the net changes in the SIC pool. This methodology employs a direct soil sampling, "measure-and-remeasure" approach.

a. **Monitoring period:** The monitoring period should be one growing season. Measurements are required at two timepoints:

i. **Time 0 (Early-season):** Before or shortly after the microbial inoculant application (defined as six weeks prior to four weeks after application),

ii. **Time t (Late-season):** When the crop reaches maturity or post-harvest (within eight months of Time 0).

11.2.2 | **Measurement of SIC:** SIC is quantified by measuring the Calcium Carbonate Equivalent (CCE %). CCE represents all inorganic carbon molecules and reports the amount of inorganic carbon as equivalent to calcium carbonate ($CaCO_3$).

a. **Isolating the Project Impact:** The quantification approach compares the change in SIC in treated units (areas receiving the microbial inoculant) against the change in SIC in baseline units (concurrent, , untreated control areas) that share similar characteristics (see Table 7. Similarity criteria for pooling and linking the baseline and the treated unit.).

i. Paired Comparison: Treated units and baseline units are grouped into pools based on similarity criteria (Soil group, Climate zone, Crop type; see Table 7. Similarity criteria for pooling and linking the baseline and the treated unit.).

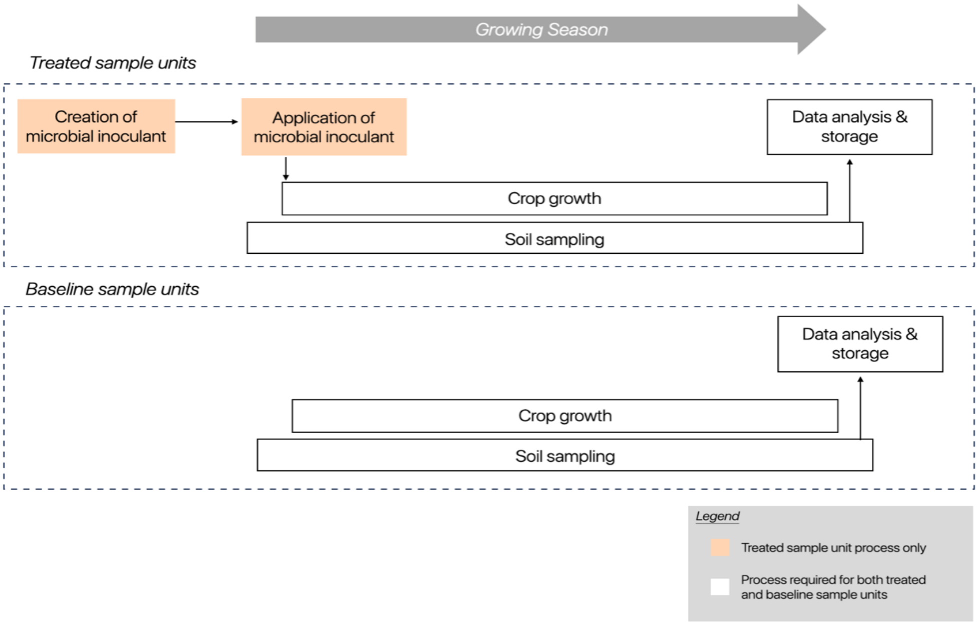
ii. Net Calculation: The change in SIC in the baseline pool is subtracted from the change in SIC in the corresponding treated pool. This isolates the impact of the microbial inoculant, ensuring that only additional removals are credited (see Section 11.4, Step 4).

b. **Conservativeness and Uncertainty:** The quantification approach includes several conservative measures:

i. **Direct Measurement Boundary:** This direct sampling approach is conservative, as it includes only CO_2 removed that is directly measured within the sampled soil depth (minimum 30 cm). Any SIC generated that percolates below the sampled depth is excluded, potentially undercounting the total CO_2 removed.

ii. **Uncertainty Deduction (UD):** To comply with the required target precision (20% of the mean at a 90% confidence level), an uncertainty deduction is applied to the treated unit pools. This deduction ensures that the credited removals are limited to the lower end of the confidence interval.

Figure 2: General overview of key project activities



11.2.3 | To ensure environmental integrity and confirm a net addition of carbon to the soil system, changes in the Soil Organic Carbon (SOC) pool shall be monitored concurrently with SIC measurements. The quantification approach accounts for potential trade-offs between carbon pools (e.g., loss of SOC due to enhanced microbial activity or "priming effect"). If a statistically significant decrease in SOC attributable to the project activity is observed, this loss shall be accounted for in the calculation of Activity Removals (AR_y). Increases in SOC stocks are not eligible for crediting under this methodology.

11.3 | Calculation of Activity Removals (AR_y)

11.3.1 | Activity Removals (ARy) are calculated based on the net changes in both the Soil Inorganic Carbon (SIC) pool (measured as CCE) and the Soil Organic Carbon (SOC) pool. SIC is quantified by measuring the Calcium Carbonate Equivalent (CCE %). SOC is quantified by measuring the Soil Organic Carbon (SOC %) or Total Organic Carbon (TOC %). The CCE % can be measured by pressure calcimeter, gas chromatography, infrared gas analyser, or gravimetric loss approaches.

11.3.2 | In addition, the following proximal sensing techniques to measure CCE are allowed: infrared spectroscopy, including near-infrared, short-wave infrared and mid-infrared spectroscopy; laser-induced breakdown spectroscopy; inelastic neutron scattering (also known as neutron-stimulated gamma ray analysis or spectroscopy); and other potential techniques not mentioned that have been published in a peer-reviewed journal. The minimum acceptable precision is R-squared greater than 0.5.

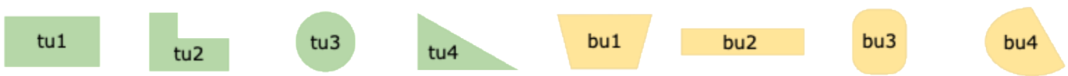
11.3.3 | Measurement procedures for SIC shall be thoroughly described, including all sample handling, analysis preparation, and analysis techniques (See Section 15).

11.3.4 | Pooling and Linking Strategy: SIC stocks are measured and remeasured directly at baseline units and treated units. To accurately attribute SIC generation to the project activity, treated units (tu) and baseline units (bu) are grouped into respective pools (tu_p and bu_p) based on the similarity criteria listed in Table 7. Similarity criteria for pooling and linking the baseline and the treated unit..

11.3.5 | Treated unit pools will be linked to baseline unit pools that share all the similarity criteria listed in Table 7. Similarity criteria for pooling and linking the baseline and the treated unit.. An illustrative project to demonstrate the pooling step is shown in Figure 3: Illustrative project to demonstrate how treated units (tu) and baseline units (bu) are grouped in different pools based on the similarity criteria table (Table 7. Similarity criteria for pooling and linking the baseline and the treated unit.).

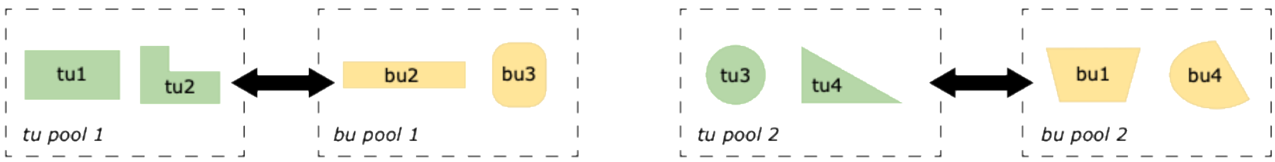
11.3.6 | It is possible that one or more treated unit pools will not share all required similarity criteria listed in Table 7. Similarity criteria for pooling and linking the baseline and the treated unit. with any baseline unit pools. Any treated unit pool without a linked baseline unit pool shall not be included in the emissions removal calculations.

Figure 3: Illustrative project to demonstrate how treated units (tu) and baseline units (bu) are grouped in different pools based on the similarity criteria table (Table 7. Similarity criteria for pooling and linking the baseline and the treated unit.)



	tu1	tu2	tu3	tu4	bu1	bu2	bu3	bu4
Treatment	Treated	Treated	Treated	Treated	Untreated	Untreated	Untreated	Untreated
Climate zone	Dfb	Dfb	Dfa	Dfa	Dfa	Dfb	Dfb	Dfa
Soil group	Luvisols	Luvisols	Luvisols	Luvisols	Luvisols	Luvisols	Luvisols	Luvisols
Crop type	Soybean	Soybean	Soybean	Soybean	Soybean	Soybean	Soybean	Soybean
Soil texture class	Silty Clay	Silty Clay	Silty Clay	Silty Clay	Silty Clay	Silty Clay	Silty Clay	Silty Clay
Tillage regime	Conventional	Conventional	Conventional	Conventional	Conventional	Conventional	Conventional	Conventional

Baseline category linking:



11.3.7 | **Uncertainty Assessment and Deduction:** Estimated GHG removals from Land Use and Forestry (LUF) activities inherently carry uncertainties associated with measurement and spatial variability. To ensure conservativeness, this methodology requires that the estimation of emission removals meets a target precision of 20% of the mean at a 90% confidence level.

11.3.8 | Uncertainty is assessed on the net impact of the project activity—the difference between the changes observed in the treated unit pools (tup) and the baseline unit pools (bup). This requires the statistical propagation of error from both pools. The methodology employs a paired-samples approach (measure-remeasure) for analyzing changes over time within units, and an independent-samples approach for analyzing the difference between the treated and baseline pools.

11.3.9 | The uncertainty assessment involves the following steps:

Step 1 Propagation of Error: The Standard Error of the Mean (SEM) for the change within each pool (calculated in Section 11.4) is used to calculate the Propagated Standard Error of the Additional Carbon (SEM_{ADC}) generated. This represents the standard error of the difference between the two independent means (tup and bup).

$$\boldsymbol{SEM_{ADC}} = \sqrt{(\boldsymbol{SEM\Delta_{tup}})^2 + (\boldsymbol{SEM\Delta_{bup}})^2} \qquad \textit{(eq. 13)}$$

Where,

SEM_{ADC}	=	Propagated Standard Error of the Additional Carbon generated
$SEM\Delta_{tup}$	=	Standard Error of the Mean change in the treated unit pool
$SEM\Delta_{bup}$	=	Standard Error of the Mean change in the baseline unit pool

11.3.10 | **Step 2: Confidence Interval (CI):** The half-width of the 90% Confidence Interval (CI) is calculated using the propagated standard error and the appropriate t-value from the Student's t-distribution.

$$\boldsymbol{CI} = \boldsymbol{SEM_{ADC}} \times \boldsymbol{t_{value}} \qquad \textit{(eq. 14)}$$

Where,

CI	=	Half-width of the 90% Confidence Interval
t_{value}	=	The t-value for a 90% confidence level (one-tailed) based on the effective degrees of freedom (df). The df shall be calculated using the Welch-Satterthwaite equation to account for potentially unequal variances and sample sizes between the treated and baseline pools.

Step 3: Precision (U%): Precision (U%) is defined as the half-width of the 90% confidence interval (CI) relative to the mean estimate of the additional carbon generated (ADC).

$$\boldsymbol{U\%} = \left(\boldsymbol{CI}/\boldsymbol{ADC}\right) \times \boldsymbol{100} \qquad \textit{(eq. 15)}$$

Where,

$U\%$	=	Precision (relative uncertainty) (%)
ADC	=	Additional Carbon Generated (the difference between the tup and bup means)

Step 4. Uncertainty Deduction (UD): If the precision target (20%) is not met, an Uncertainty Deduction (UD) shall be applied. The UD is equal to the half-width of the 90% confidence interval.

$$If\ U\% \leq 20\%: UD = 0\ ;\ If\ U\% > 20\%: UD = CI \qquad (eq.\ 3)$$

The UD shall always be applied in the most conservative manner. When the ADC represents a removal (positive value), the UD is subtracted. When the ADC represents an emission or loss (negative value), the UD (a positive value) is added, thereby magnifying the calculated loss. This ensures that the final accounted impact is limited to the conservative bound of the 90% confidence interval. The detailed application is provided in Section 11.4, Step 5.

11.4 | Step-by-Step Calculation of Gross GHG Removals

11.4.1 | The following steps detail the calculation of emissions removals attributable to the project activity, integrating measurements of both Soil Inorganic Carbon (as CCE) and Soil Organic Carbon (SOC). This methodology utilizes a paired-samples approach for analyzing changes over time (Time 0 to Time t) and an independent-samples approach for analyzing the difference between treated and baseline pools.

Step 1: Calculate Mean CCE and SOC for Individual Units

11.4.2 | Calculate the mean CCE and SOC for each treated unit (tu) and baseline unit (bu) at the beginning (Time 0) and end (Time t) of the monitoring period, based on the sampling points within each unit.

Calcium Carbonate Equivalent (CCE):

$$\boldsymbol{Mean\ CCE_{tu,0} = \frac{\Sigma CCE_{tu,0}}{\#\ of\ points_{tu,0}}} \qquad (eq.\ 17)$$

$$\boldsymbol{Mean\ CCE_{tu,t} = \frac{\Sigma CCE_{tu,t}}{\#\ of\ points_{tu,t}}} \qquad (eq.\ 18)$$

$$Mean\ CCE_{bu,0} = \frac{\Sigma CCE_{bu,0}}{\#\ of\ points_{bu,0}} \qquad (eq.\ 19)$$

$$Mean\ CCE_{bu,t} = \frac{\Sigma CCE_{bu,t}}{\#\ of\ points_{bu,t}} \qquad (eq.\ 20)$$

Soil Organic Carbon (SOC):

$$\boldsymbol{Mean\ SOC_{tu,0} = \frac{\Sigma SOC_{tu,0}}{\#\ of\ points_{tu,0}}} \qquad (eq.\ 214)$$

$$\boldsymbol{Mean\ SOC_{tu,t} = \frac{\Sigma SOC_{tu,t}}{\#\ of\ points_{tu,t}}} \qquad (eq.\ 22)$$

$$Mean\ SOC_{bu,0} = \frac{\Sigma SOC_{bu,0}}{\#\ of\ points_{bu,0}} \qquad (eq.\ 23)$$

$$Mean\ SOC_{bu,t} = \frac{\Sigma SOC_{bu,t}}{\#\ of\ points_{bu,t}} \qquad (eq.\ 245)$$

Where:

$Mean\ CCE/SOC_{u,0/t}$	=	Mean CCE or SOC of all samples within the unit (tu or bu) at time 0 or t (CCE % or SOC %)
$\Sigma CCE/SOC_{u,0/t}$	=	Sum of CCE or SOC from all samples taken within the unit at time 0 or t
$\#\ of\ points_{tu,0/t}$	=	Number of sampling points within the unit at time 0 or t

Step 2: Calculate the Change (Δ) in CCE and SOC for Individual Units

11.4.3 | To utilize a paired-samples statistical approach (measure-and-remeasure), the change over the monitoring period (t-0) shall be calculated at the individual unit level.

$$\Delta\ \boldsymbol{CCE_{tu,t-0}} = \boldsymbol{Mean\ CCE_{tu,t} - Mean\ CCE_{tu.0}} \quad \textit{(eq. 25)}$$

$$\Delta\ \boldsymbol{CCE_{bu,t-0}} = \boldsymbol{Mean\ CCE_{bu,t} - Mean\ CCE_{bu.0}} \quad \textit{(eq.26)}$$

$$\Delta\ \boldsymbol{SOC_{tu,t-0}} = \boldsymbol{Mean\ SOC_{tu,t} - Mean\ SOC_{tu.0}} \quad \textit{(eq.27)}$$

$$\Delta\ \boldsymbol{SOC_{bu,t-0}} = \boldsymbol{Mean\ SOC_{bu,t} - Mean\ SOC_{bu.0}} \quad \textit{(eq.28)}$$

Where:

$\Delta\ CCE/SOC_{u,0/t}$	=	Change in mean CCE or SOC within the unit (tu or bu) during the monitoring period (CCE % or SOC %)

Step 3: Calculate the Mean Change (Δ) and Statistics for Unit Pools

11.4.4 | Calculate the mean change, standard deviation (s) of the change, and Standard Error of the Mean (SEM) of the change for each treated unit pool (tup) and baseline unit pool (bup).

Example calculation for CCE in a treated unit pool (tup):

$$\boldsymbol{Mean\ \Delta CCE_{tup,t-0}} = \frac{\Sigma(\Delta CCE_{tu,t-0})}{\#\ of tu_{tup}} \quad \textit{(eq.29)}$$

$$\boldsymbol{s\Delta CCE_{tup} = StDEV(\Delta CCE_{tu,t-0}\ values\ with\ in\ the\ pool)} \quad \textit{(eq.30)}$$

$$\boldsymbol{SEM\ \Delta CCE_{tup}} = \boldsymbol{s\Delta CCE_{tup}} \Big/ \sqrt{\boldsymbol{\#\ of tu_{tup}}} \quad \textit{(eq.31)}$$

Where:

$Mean\ \Delta CCE_{tup,t-0}$	=	Mean of the changes in CCE across all treated units within the pool (CCE %)

$s\Delta CCE_{tup}$	=	Standard deviation of the changes in CCE within the pool
$SEM\ \Delta CCE_{tup}$	=	Standard Error of the Mean change in CCE within the pool
$\#\ of tu_{tup}$	=	Number of treated units in the pool

(Note: The project developer shall perform these calculations (Mean, s, SEM) for all four pool variables: $\Delta\ CCE_{tup}$, $\Delta\ CCE_{bup}$, $\Delta\ SOC_{tup}$ and $\Delta\ SOC_{bup}$)

Step 4: Calculate Additional Carbon Generated (ADC) and Propagated Uncertainty

11.4.5 | Calculate the additional carbon generated (ADC) attributable to the treatment by subtracting the mean change in the baseline pool from the mean change in the corresponding treated pool. Calculate the propagated standard error of this addition (SEM_{ADC}).

Additional CCE Generated (ADCCE):

$$\boldsymbol{ADCCE_{tup,t-0} = Mean\ \Delta CCE_{tup,t-0} - Mean\ \Delta\ CCE_{bup.t-0}} \qquad (eq.32)$$

$$\boldsymbol{SEM_{ADDCCE\_tup} = \sqrt{\left(SEM\Delta CCE_{tup}\right)^2 + \left(SEM\Delta CCE_{bup}\right)^2}} \qquad (eq.33)$$

Additional SOC Generated (ADSOC):

$$\boldsymbol{ADSOC_{tup,t-0} = Mean\ \Delta SOC_{tup,t-0} - Mean\ \Delta\ SOC_{bup,t-0}} \qquad (eq.34)$$

$$\boldsymbol{SEM_{ADDSOC\_tup} = \sqrt{\left(SEM\Delta SOC_{tup}\right)^2 + \left(SEM\Delta SOC_{bup}\right)^2}} \qquad (eq.35)$$

Where:

$ADCCE/SOC_{tup,t-0}$	=	Additional CCE or SOC generated during the monitoring period attributable to the treatment for the treated unit pool (CCE % or SOC %)
SEM_{ADDCCE/SOC_tup}	=	Propagated Standard Error of the Additional CCE or SOC generated (Standard error of the difference between the two independent means)

Step 5: Apply Uncertainty Deduction (Conservativeness)

11.4.6 | Calculate the precision (U%) of the additional carbon generated estimate. If the target precision (20% of the mean at 90% confidence level) is not met, apply an Uncertainty Deduction (UD). The following steps apply identically to both CCE (ADCCE) and SOC (ADSOC), collectively referred to as ADC.

11.4.7 | Calculate the Confidence Interval (CI) half-width:

$$\boldsymbol{CI_{tup} = SEM_{ADC\_tup} \times t_{value}} \qquad (eq.\ 36)$$

Where:

CI_{tup}	=	Half-width of the 90% Confidence Interval for the additional carbon generated (CCE % or SOC %)
SEM_{ADC_tup}	=	Propagated Standard Error (from Step 4)
t_{value}	=	The t-value from the Student's t-distribution for a 90% confidence level (one-tailed) based on the effective degrees of freedom (df). The df shall be calculated using the Welch-Satterthwaite equation to account for potentially unequal variances and sample sizes between the treated and baseline pools.

11.4.8 | Calculate Precision (U%):

$$\boldsymbol{U\%_{tup}} = \left(\frac{\boldsymbol{CI_{tup}}}{\boldsymbol{ADC_{tup,t-0}}}\right) \qquad \textit{(eq. 37)}$$

Where:

$U\%_{tup}$	=	Precision (relative uncertainty) (%)
$ADC_{tup,t-0}$	=	Additional Carbon Generated (from Step 4)

11.4.9 | Determine Uncertainty Deduction (UD):

$$\boldsymbol{If\ U\%_{tup} \leq UD_{tup} = 0; If\ U\%_{tup} > UD_{tup} = CI_{tup}} \qquad \textit{(eq. 38)}$$

11.4.10 | Calculate the Adjusted Additional Carbon Generated (Adj_{ADC}): The UD shall be applied conservatively:

$$If\ \boldsymbol{ADC_{tup,t-0}} > 0\ (A\ net\ removal): \boldsymbol{ADC_{tup,t-0}} = \boldsymbol{ADC_{tup,t-0}} - \boldsymbol{UD_{tup}} \qquad \textit{(Eq. 39)}$$

$$If\ \boldsymbol{ADC_{tup,t-0}} < 0\ (A\ net\ emission/loss): \boldsymbol{ADC_{tup,t-0}} = \boldsymbol{ADC_{tup,t-0}} + \boldsymbol{UD_{tup}} \qquad \textit{(Eq. 40)}$$

(Note: Adding the positive UD to the negative ADC magnifies the calculated loss.)

$$If\ \boldsymbol{ADC_{tup,t-0}} = 0: \boldsymbol{Adj_{ADC}} = 0 \qquad \textit{(eq. 41)}$$

(Note: The project developer shall calculate both the $Adj_{ADCCEtup,t-0}$ and $Adj_{ADSOCtup,t-0}$)

Step 6 Convert Adjusted Additional Carbon to Tonnes of CO_2 Removed per Hectare

11.4.11 | **Calculate Soil Mass per Hectare (TSH):** Average soil bulk density (BD) for the pool shall be calculated based on direct measurements (see Section 15.2), weighted by the units' area.

$$BD_{tup} = \sum_{i=1}^{n}(BD \times Area_i) \Big/ \sum_{i=1}^{n}(Area_i) \quad \textit{(eq. 42)}$$

$$TSH_{tup} = MSH \times BD_{tup} \quad \textit{(eq. 43)}$$

Where:

BD_{tup}	=	Area-weighted soil bulk density of the treated unit pool (g/cm³ or tonnes/m³)
TSH_{tup}	=	Tonnes of soil per hectare within the sampled depth (tonnes of soil/hectare)
MSH	=	Volume of soil per hectare within the sampled depth (m³/hectare). (e.g., 3,000 m³/ha for a 30 cm sampling depth). *(Note: 1 g/cm³ = 1 tonne/m³)*

11.4.12 | Calculate Tonnes of CO_2e/ha (TCO_2H): tonnes of CO_2e/ha from SIC (tCO_2HSIC):

$$TCO2H_{SIC\_tup} = \left(\frac{Adj_{ADCCE,tup,t-0}}{100}\right) \times TSH_{tup} \times 0.44 \quad \textit{(eq. 44)}$$

Where: 0.44 = Conversion of CaCO3 to CO_2 based on the molecular weight (MW) ratio (MW CO_2 / MW CaCO3 = 44.009/100.09).

11.4.13 | Tonnes of CO_2e/ha from SOC (TCO2H_SOC):

$$TCO2H_{SOC\_tup} = \left(\frac{Adj_{ADSOC,tup,t-0}}{100}\right) \times TSH_{tup} \times 3.67 \quad \textit{(eq. 45)}$$

Where: 3.67 = Conversion of C to CO_2 based on the molecular weight (MW) ratio (MW CO_2 / MW C = 44.009/12.01

11.4.14 | Total tonnes of CO_2e/ha (TCO_2Htup):

$$TCO2H_{tup,t-0} = TCO2H_{SIC\_tup} + min(0, TCO2H_{SOC\_tup}) \quad \textit{(eq. 46)}$$

(Note: If $TCO2H_{SOC\_tup}$ is negative, representing a loss of SOC attributable to the project, this equation correctly accounts for that loss against any SIC gains.)

Step 7: Calculate Total Gross Activity Removals (AR_y)

11.4.15 | Total tonnes of CO_2 removed from the atmosphere within each treated unit pool (TTtup) is determined as follows:

$$TT_{tup,t-0} = TCO2H_{tup,t-0} \times \#\ of\ hectares_{tup} \quad \textit{(eq. 47)}$$

Where:

$TT_{tup,t-0}$	=	Total tonnes of CO_2 removed during the monitoring period within the treated unit pool

(tonnes of CO_2)

$\# \, of \, hectares_{tup}$	=	Total area, in hectares, of the treated unit pool (hectare)

11.4.16 | Total gross tonnes of CO_2 removed from the atmosphere attributable to the treatment is determined as follows:

$$\boldsymbol{AR_y = \sum_{i=1}^{m} TT_{tup_i,t-0}} \qquad \textit{(eq. 48)}$$

Where:

$TT_{tup_i,t-0}$	=	Total tonnes of CO_2 removed from the atmosphere during the monitoring period attributable to the treatment within each treated unit pool (tup) (tonnes of CO_2)
m	=	Total number of treated unit pools (tup)

12| CALCULATION OF NET GHG REMOVALS

The calculation of Net GHG Removals involves sequential steps: calculating the initial net removals, applying the Downward Adjustment Factor, calculating the buffer contribution, and determining the final issued GS-VERs.

12.1 | Calculation of Initial Net GHG Removals ($ER_{initial,y}$)

12.1.1 | The initial Net GHG Removals in monitoring period *y* ($ER_{intial,y}$) shall be calculated as the total Activity Removals minus the Activity Emissions and Leakage Emissions.

$$\boldsymbol{ER_{initial,y} = AR_y - AE_y - LE_y} \qquad \textit{(eq. 496)}$$

Where:

$ER_{intial,y}$	=	Initial Net GHG Removals for the monitoring period *y* (tonnes of CO_2)
AR_y	=	Total Activity Removals (Gross removals) during the monitoring period *y* (tCO_2) (tonnes of CO_2)
AE_y	=	Total Activity Emissions during the monitoring period *y* (tCO_2e). (Calculated in Section 9).
LE_{y}	=	Total Leakage Emissions during the monitoring period y (tCO_2e). (Calculated in Section 10; includes $LE_{IS,y}$, while $LE_{AS,y}$ is addressed via adjustments to AR_y).

12.2 | Application of the Downward Adjustment Factor (DAF)

12.2.1 | To ensure ambition over time, a Downward Adjustment Factor (DAF) shall be applied to the initial Net GHG Removals, in accordance with the GS4GG *Downward Adjustment Factor (DAF) Determination Tool*.

12.2.2 | **Rationale and Application:** As this methodology pertains to Carbon Dioxide Removal (CDR) activities, the Absolute DAF Floor value shall be applied. The DAF is applied as a deduction to the Initial Net GHG Removals to ensure the adjustment meaningfully enhances ambition.

12.2.3 | **Timing and Values:** The DAF is applied based on the calendar year in which the removals occur, independent of the project's crediting period start date. The applicable calendar year (y) is determined by the end date of the monitoring period (Time t, the date of the late-season sampling). The values for $DAF_{NetZero,y}$ are based on the current version of the DAF Determination Tool:

12.2.4 | For Calendar Year (y) i.e., pre - 2026, the applicable $DAF_{NetZero,y}$ Value (Absolute Floor) 0%.

12.2.5 | For Calendar Year (y) i.e., 2026 ≤ y ≤ 2030, the applicable $DAF_{NetZero,y}$ Value (Absolute Floor) 1.25%.

12.2.6 | The DAF values and application periods shall be updated according to the latest applicable version of the GS4GG DAF Determination Tool for periods starting after 2030.

12.3 | Calculation of Adjusted Net GHG Removals ($ERadjustedy$)

12.3.1 | The Adjusted Net GHG Removals ($ERadjustedy$) are calculated as follows:

$$\boldsymbol{ER_{adjusted,y} = ER_{intial,y} \times \left(1 - DAF_{Net-Zero,y}\right)} \qquad (eq.\ 50)$$

Where:

$ER_{adjusted,y}$	=	Adjusted Net GHG Removals for the monitoring period *y* (tCO_2e)
$ER_{intial,y}$	=	Initial Net GHG Removals for the monitoring period *y* (tCO_2e)
$DAF_{Net-Zero,y}$	=	Downward Adjustment Factor applicable to the calendar year *y* (unitless)

12.4 | Calculation of Buffer Contribution and Issuable GSVERs

12.4.1 | The final GSVERs issued is determined after accounting for the contribution to the Compliance Buffer (see Section 14.4).

12.4.2 | Buffer Contribution (BC_y): The contribution to the Gold Standard Compliance Buffer is calculated based on the Adjusted Net GHG Removals.

$$\boldsymbol{BC_y = ER_{adjusted,y} \times R_{buffer}} \qquad (eq.\ 51)$$

Where:

BC_y	=	Contribution to the Compliance Buffer in monitoring period *y* (tCO_2e)
$ER_{adjusted,y}$	=	Adjusted Net GHG Removals for the monitoring period y (tCO_2e)
R_{buffer}	=	Required Buffer Contribution Rate (0.20 or 20%) (see Section 14.4)

12.4.3 | Issuable GSVERs (VERy): The total number of GSVERs issued for the monitoring period *y* is calculated as follows:

$$\boldsymbol{Issuable\ GSVERs = ER_{adjusted,y} - BC_y} \qquad (eq.52)$$

13| MEETING METHODOLOGICAL PRINCIPLES

This section details how the methodology adheres to the core principles required for robust and credible greenhouse gas accounting.

13.1 | Encouraging ambition over time

13.1.1 | The methodology encourages ambition over time through several key design features:

a. **Dynamic, Directly Measured Baseline:** This methodology utilizes a dynamic baseline based on existing actual removals, measured concurrently via control plots (baseline units) during each monitoring period (Section 7). This ensures that the baseline always reflects the current conditions and prevailing practices. Any autonomous improvements in SIC sequestration that might occur are automatically captured, ensuring that only additional removals are credited.

b. **Promotion of Nascent Technology:** The methodology facilitates the adoption of an innovative Carbon Dioxide Removal (CDR) pathway. As confirmed by the Common Practice Analysis (Annex 02), this technology is categorized as TMC-1 (Innovator/Nascent) with 0% autonomous market adoption. Supporting the scaling of such solutions is inherently ambitious.

c. **Periodic Review and Renewal:** The validity of the methodology-level additionality assessments (Common Practice Analysis and Deemed Financial Additionality) is limited to three years from the publication date. Reassessment is required upon methodology renewal. Furthermore, at the renewal of the crediting period, projects shall apply the latest version of the methodology (Section 17). These requirements ensure that baseline and additionality assumptions remain appropriate and ambitious relative to evolving science, market conditions, and technological advancements.

d. **Application of Downward Adjustment Factor (DAF):** To ensure environmental integrity and increase ambition over time, the methodology requires the application of a Downward Adjustment Factor (DAF) to the net GHG removals, in accordance with the latest version of the GS4GG *Downward Adjustment Factor (DAF) Determination Tool*. This factor applies a conservative deduction to the calculated removals during specific calendar periods (see Section 12.2).

13.2 | Equitable sharing of mitigation benefits

13.2.1 | The methodology is designed to facilitate the equitable sharing of mitigation benefits by promoting participation among agricultural stakeholders:

13.2.2 | **Integration with Existing Practices:** The activity integrates seamlessly into existing cropland operations without requiring specialized infrastructure or significant changes in management practices (other than the inoculant application).

13.2.3 | **Revenue Diversification:** The methodology enables farm operators, including smallholders, to access carbon finance, providing a diversified revenue stream that can enhance the economic resilience of agricultural communities.

13.2.4 | **Maintaining Productivity:** The methodology includes rigorous safeguards against leakage (Section 10), requiring that agricultural productivity is maintained, ensuring that food security objectives are not compromised.

13.3 | Avoidance of double counting

13.3.1 | To mitigate the risk of double issuance and claims, the project developer shall conform with the requirements and procedures set forth in the GHG Emissions Reduction & Sequestration Product Requirements that no double-counting takes place.

13.3.2 | Furthermore, the methodology specifically addresses potential overlap with other soil carbon initiatives:

a. **Exclusion of Other SIC Programs:** The Applicability Criteria explicitly prohibit the implementation of other SIC-focused programs within the project area (Section 2).

b. **Distinct Carbon Pools (SIC vs. SOC):** This methodology quantifies removals based on the direct measurement of Soil Inorganic Carbon (SIC), measured as CCE. As this measures a distinct carbon pool from Soil Organic Carbon (SOC), the methodology is compatible with regenerative agriculture programs focused on SOC enhancement in the same project area, provided those programs also adhere to robust accounting principles that avoid the double counting of specific emission sources or sinks.

13.4 | Aligning with NDC and LT-LEDS

13.4.1 | This methodology supports alignment with host countries' Nationally Determined Contributions (NDCs) and Long-Term Low-Emission Development Strategies (LT-LEDS) by providing a pathway for durable Carbon Dioxide Removal (CDR) within the agricultural sector. Many NDCs identify sustainable agriculture and carbon sequestration as key mitigation strategies. This methodology provides a robust framework for quantifying, monitoring, and verifying GHG removals from agricultural activities, contributing directly to national climate targets while promoting sustainable land management.

13.5 | Encouraging broad participation

13.5.1 | The methodology is designed to encourage broad participation by minimizing barriers to implementation and maximizing applicability:

a. **Geographic and Sectoral Coverage:** The methodology is globally applicable and relevant to a wide variety of common crops, soil types, and climate zones (Section 2).

b. Operational Simplicity: The project activity utilizes existing agricultural equipment and requires minimal changes to standard farming operations, facilitating adoption by a wide range of farm operators.

c. Scalability and Aggregation: The methodology is applicable to micro, small, and large-scale activities, and supports implementation via a Programme of Activities (PoA) (Section 17), which can reduce transaction costs and facilitate the inclusion of smallholder farmers.

d. **Data Accessibility:** While requiring rigorous direct measurement, the methodology allows the use of publicly accessible national or global databases for stratification (e.g., soil texture) and pooling criteria (e.g., WRB Soil Groups, Köppen-Geiger climate zones), addressing potential data gaps (Section 15.1).

13.6 | Including data sources, accounting for uncertainty, and monitoring

13.6.1 | The methodology ensures robustness in data sourcing, monitoring, and uncertainty management through the following provisions:

a. **Direct Measurement:** The quantification of emission removals relies on direct soil sampling and laboratory analysis of SIC (CCE) rather than relying primarily on models or default emission factors. This minimizes uncertainty associated with estimation parameters.

b. **Rigorous Monitoring (MRV):** The monitoring methodology (Section 15) prescribes a rigorous monitoring, reporting, and verification (MRV) system, including stratified random sampling design, specific requirements for sampling depth and frequency, standardized laboratory analysis procedures, and comprehensive QA/QC protocols, including sample archiving.

c. **Explicit Uncertainty Quantification and Deduction:** The methodology explicitly addresses uncertainty associated with the measurement of SIC stocks. It requires the calculation of statistical uncertainty (U) based on the Standard Error of the Mean (SEM). To ensure conservativeness and meet the required precision target (20% of the mean at a 90% confidence level), an explicit Uncertainty Deduction (UD) is applied. This ensures that credited removals are limited to the lower end of the confidence interval.

13.7 | Taking into account policies, measures and relevant circumstances

13.7.1 | The methodology requires that relevant national, regional, or local circumstances are accounted for in the project design and implementation:

a. **Regulatory Compliance:** A mandatory Regulatory Analysis (Section 6.2) ensures that the project activity is not mandated by existing laws and complies with all relevant national and local regulations, including the legal registration of the microbial inoculant.

b. **Site-Specific Applicability:** Applicability criteria ensure the activity is appropriate for the local context, including requirements regarding existing land use (cropland), soil conditions (pH ≥ 6.3), and resource availability (exclusion of irrigated land) (Section 2).

c. **Context-Specific Quantification:** The methodology mandates the stratification of fields based on local soil characteristics (soil texture) and requires that baseline and treated units are pooled based on key contextual factors (Soil Group, Climate Zone, Crop Type) (Section 7.4). This ensures that the quantification of removals accurately reflects the specific environmental and technological circumstances of the project area.

14| REVERSALS

14.1 | Durability and Definition of Reversal

14.1.1 | This methodology facilitates Carbon Dioxide Removal (CDR) by converting atmospheric CO_2 into Soil Inorganic Carbon (SIC), which exists in durable mineral and ionic forms (e.g., $CaCO_3$). A reversal (non-permanence) occurs if the sequestered SIC is dissolved and subsequently degasses as CO_2 back into the atmosphere.

14.1.2 | The durability of the SIC generated is inherently high. Unlike Soil Organic Carbon (SOC), SIC is not subject to microbial decomposition. As the SIC moves down the soil profile through natural hydrological processes and eventually reaches long-lived reservoirs (groundwater, rivers, and the ocean), the durability is estimated to be on the order of 10,000 years or more (Section 2).

14.2 | Assessment of Reversal Risks

14.2.1 | While SIC is highly durable, the risk of reversal shall be assessed as the methodology falls under the Agriculture Activity Requirements. The primary mechanism for SIC reversal within the soil profile is dissolution under acidic conditions. The assessment of risks that could lead to such conditions is summarized below:

a. Avoidable Risks

14.2.2 | **Soil Acidification (Management Practices):** The adoption of management practices that significantly lower soil pH (e.g., excessive application of highly acidifying fertilizers or amendments) could cause the dissolution of SIC.

14.2.3 | **Land Use Change and Management:** Conversion of the project area to land uses associated with high acidity or significantly altered hydrology (e.g., wetlands), or the introduction of prohibited practices (e.g., irrigation).

b. Unavoidable Risks

14.2.4 | **Soil Erosion:** Severe erosion events could lead to the physical loss of SIC-rich topsoil. This primarily represents a displacement of the carbon stock rather than an immediate reversal (emission), unless the eroded material is transported to a highly acidic environment.

14.2.5 | **Natural Acidification:** While natural processes can lead to soil acidification, this typically occurs over long timescales (decades to centuries) and is unlikely to cause significant reversals during the project monitoring horizon, especially in soils meeting the methodology's pH criteria.

c. Overall Risk Conclusion

14.2.6 | The inherent chemical stability of mineralized carbon (SIC) means the risk of reversal is significantly lower than that associated with biogenic carbon (e.g., SOC). Provided the soil environment remains chemically stable (i.e., pH is maintained above the threshold), the risk of significant reversal is considered low.

14.3 | Risk Mitigation Measures

14.3.1 | The methodology integrates several mandatory requirements to mitigate the identified reversal risks:

a. **Soil pH Requirement:** The methodology requires that the project area (both treated and baseline units) maintains an average pH equal to or higher than 6.3 (Section 2). Carbonates are chemically stable within this pH range, directly mitigating the primary risk of acid dissolution.

b. **Land Use and Hydrology Restrictions:** The methodology is restricted to existing cropland and explicitly prohibits land-use change. It is also not applicable to wetlands (often naturally acidic) or irrigated land (Section 2).

c. **Management Practice Restrictions:** The methodology prohibits changes in field management practices such as increased synthetic fertilizer application (Section 2), which helps mitigate the risk of management-induced acidification.

d. **Monitoring:** Soil pH and land use compliance are monitored throughout the crediting period (Section 15) to verify that the conditions for SIC stability are maintained.

14.4 | Addressing Reversals (The Buffer Approach)

14.4.1 | To address potential unavoidable reversals (e.g., due to natural hazards), this methodology complies with the *GHG Emissions Reduction & Sequestration Product Requirements* and the *Agriculture Activity Requirements* by utilizing the Gold Standard Compliance Buffer.

14.4.2 | In accordance with the standard requirements for projects applying the *Agriculture Activity Requirements*, a fixed percentage of the issued GSVERs shall be transferred into the Gold Standard Compliance Buffer. The required contribution is **20%** of the Net GHG Removals (ERy) calculated in Section 12 (Equation 37).

14.5 | Monitoring for Reversals and Liability

14.5.1 | The project developer is responsible for monitoring the project area to identify any potential reversal risks or events throughout the crediting period, and for the duration specified in the latest version of the Agriculture Activity Requirements.

14.5.2 | Monitoring includes:

14.5.2.1 | **Soil pH Monitoring:** As detailed in Section 15.2, soil pH shall be measured during the early-season sampling event (Time 0) to verify ongoing compliance with the applicability condition (pH ≥ 6.3).

14.5.2.2 | **Land Use and Management Monitoring:** The project developer shall monitor and document that the land use remains as eligible cropland and that no prohibited management changes have occurred.

14.5.2.3 | **Liability:** If a reversal event is detected, the project developer shall quantify the magnitude of the reversal and report it in the monitoring report.

14.5.2.4 | **Unavoidable Reversals:** Gold Standard shall retire the corresponding number of credits from the Compliance Buffer to compensate for the reversal.

14.5.2.5 | **Avoidable Reversals:** The Project Developer is liable for reversals resulting from avoidable risks (e.g., non-compliance with methodology requirements). The buffer cannot be used to cover avoidable reversals, and the Project Developer shall compensate for such losses according to the procedures outlined in the GHG Emissions Reductions & Sequestration Product Requirements.

15| MONITORING METHODOLOGY

15.1 | Data and parameters not monitored

15.1.1 | The following parameters are determined ex-ante, are fixed for the crediting period, or are sourced from external, reputable databases where direct monitoring by the project developer during each monitoring period is not required.

Parameter ID	**1**
Data/parameter:	Soil texture
Description	The relative proportion of different-sized mineral particles, such as sand, silt, and clay, in a soil sample
Data unit:	N/A
Purpose of the data	☒ Baseline emissions/removals ☒ Activity emissions /removals (Used for stratification and pooling, Table 7) ☐ Leakage emissions
Value(s) applied:	N/A
Source of data	☐Measured ☒Other – External databases
Choice of data or measurement methods and procedures:	Sourced primarily from national or local soil databases (e.g., USDA SSURGO). If unavailable, global soil databases (e.g., FAO, ISRIC) shall be used.
Treatment of uncertainty	-
Comments:	Soil texture is used as the criterion to stratify the fields within the project area for sampling design (Section 15.3).

Parameter ID	**2**
Data/parameter:	Soil group
Description	Soil classification according to the World Reference Base (WRB) for Soil Resources system. Soils are categorized into different reference soil groups (RSGs), each representing a distinct type of soil with specific characteristics.
Data unit:	N/A
Purpose of the data	☒ Baseline emissions/removals ☒ Activity emissions /removals (Used for pooling, Table 7) ☐ Leakage emissions
Value(s) applied:	N/A

Source of data	☐Measured ☒Other
Choice of data or measurement methods and procedures:	ISRIC, World Soil Information[9], or other verified global/regional soil maps utilizing the WRB system.
Treatment of uncertainty	-
Comments:	Soil group is one of the similarity criteria used to link baseline units to treated units (Section 7.4).

Parameter ID	**3**
Data/parameter:	Climate zone
Description	The Köppen-Geiger climate classification is one of the most widely used systems for classifying the world's climates based on temperature and precipitation patterns. The classification divides climates into five main groups, each based on seasonal precipitation and temperature patterns.
Data unit:	N/A
Purpose of the data	☒ Baseline emissions/removals ☒ Activity emissions /removals (Used for pooling, Table 7) ☐ Leakage emissions
Value(s) applied:	N/A
Source of data	☐Measured ☒Other - External Databases/Maps
Choice of data or measurement methods and procedures:	Established world maps of Köppen-Geiger climate classification[10] based on the GPS coordinates of the fields.
Treatment of uncertainty	-
Comments:	Climate zone is one of the similarity criteria used to link baseline units to treated units (Section 7.4).

Parameter ID	**4**
Data/parameter:	MSH (Volume of soil per hectare within the sampled depth)
Description	The volume of soil per hectare corresponding to the sampling depth utilized in the project.

[9] https://soilgrids.org
[10] https://koeppen-geiger.vu-wien.ac.at/present.htm

Data unit:	m^3/hectares
Purpose of the data	☐ Baseline emissions/removals ☒ Activity removals ☐ Leakage emissions
Value(s) applied:	N/A
Source of data	☒Measured Calculated Constant ☐Other
Choice of data or measurement methods and procedures:	Calculated based on the sampling depth used. For the minimum required depth of 30 cm (0.3 m), MSH = 10,000 m^2/ha * 0.3 m = 3,000 m^3/ha.
Treatment of uncertainty	-
Comments:	The sampling depth shall be fixed for the project area and consistently applied. If a depth greater than 30 cm is used, this value shall be adjusted.

Parameter ID	**5**
Data/parameter:	Historical Land Use and Management
Description	Information confirming the historical land use and management practices of the project area prior to the project start date.
Data unit:	N/A
Purpose of the data	☒ Applicability Criteria
Value(s) applied:	N/A
Source of data	Remote Sensing/Records
Choice of data or measurement methods and procedures:	Determined ex-ante via farm operator records, historical satellite imagery, or national land use databases. Evidence shall confirm compliance with Section 2 (e.g., existing cropland for ≥5 years; no forest within 10 years prior; not wetland or irrigated land).
Treatment of uncertainty	-
Comments:	Determined at validation and reassessed if new areas are added to the project.

Parameter ID	**6**
Data/parameter:	Microbial Inoculant Registration and Safety Data
Description	Evidence of legal registration, safety compliance, and composition of the microbial inoculant.
Data unit:	N/A

Purpose of the data	☒ Applicability Criteria
Value(s) applied:	N/A
Source of data	Official documentation
Choice of data or measurement methods and procedures:	Official registration documents from the relevant national or subnational agricultural authority, evidence of compliance with relevant safety regulations (e.g., Regulation (EU) 2019/1009 or similar), and confirmation of non-GMO status.
Treatment of uncertainty	-
Comments:	Determined at validation and reassessed if the inoculant product changes.

Parameter ID	**7**	
Data/parameter:	Average crop yield	
Description	Growers, USDA Actual Production History data, industry, peer-reviewed, academic, or international organization (e.g., FAO) sources	
Data unit:	Tonnes of grain or biomass per hectare	
Purpose of the data	☒ Leakage emissions	
Value(s) applied:	N/A	
Source of data	☐Measured	☒Other
Choice of data or measurement methods and procedures:	Not measured	
Treatment of uncertainty	-	
Comments:	Crop yield data is not collected for every field; it is collected only for particular field(s) reported by growers to have a reduction in yield. In that case, regional yield data for the relevant crop may also be collected for the purpose of comparison. See Section 10.3 for details.	

15.2 | Data and parameters monitored

15.2.1 | The following parameters shall be monitored during each monitoring period *y*.

Parameter ID	**8**
Data/parameter:	Calcium Carbonate Equivalent (CCE)

Description:	Measurement of all inorganic carbon molecules (SIC) in the soil, expressed as $CaCO_3$ equivalent.
Data unit:	Weight %
Source of data	Directly measured from soil samples
Purpose of the data	☒ Baseline removals ☒ Activity removals ☐ Leakage emissions
Measurement and updating frequency	Twice per growing season: at time 0 (i.e., early-season timepoint) and time t (i.e., late-season timepoint). See Section 15.3 for timing windows.
Measurement methods and procedures:	Measured via laboratory analysis of soil samples collected according to Section 15.3. Acceptable methods include: a. Acid dissolution methods (e.g., pressure calcimeter or modified-pressure calcimeter, gas chromatography or infrared gas analyser, coulometry, gravimetric loss) b. Dry-combustion methods (e.g., elemental analyser with infrared detection, thermal combustion with gas chromatography) c. Soil spectroscopy[11] The same procedure shall be used for all samples within a monitoring period.
Measuring instrument(s):	Varies by method (e.g., Pressure Calcimeter, Elemental Analyzer). Instruments shall be calibrated according to manufacturer specifications and laboratory standards. Calibration records shall be maintained.
QA/QC procedures:	Laboratories shall attest to their QA/QC procedures (Section 15.3). Procedures include standardized sample handling, drying, grinding (≤ 2 mm), and archiving of samples for at least two years after credit verification.
Comments:	The baseline units and treated units samples should use the same measurement procedure to quantify CCE.

Parameter ID	**9**
Data/parameter:	Soil pH
Description:	Measure of the acidity or alkalinity of a soil
Data unit:	Dimensionless

[11] If an indirect measurement method is used, its associated model must be peer-reviewed.

Source of data	Measured (Soil samples)
Purpose of the data	☒ Reversal Risk Monitoring
Measurement and updating frequency	Once per monitoring period (growing season) at Time 0 (early-season timepoint).
Measurement methods and procedures:	Measured via laboratory analysis of soil samples using the soil water suspension method. The measurement approach shall be consistent across all samples.
Measuring instrument(s):	pH meter/probe. Instruments shall be calibrated using standard buffer solutions according to manufacturer specifications before analysis.
QA/QC procedures:	As detailed for Parameter 10. Used to verify ongoing compliance with Applicability Criteria (pH ≥ 6.3).
Comments:	Soil pH shall be measured at time 0 (i.e., early-season timepoint) on all the sampling points. Measurement at time t (i.e., late-season timepoint) is not required. The pH measurement approach shall be consistent across all samples in a given project.

Parameter ID	**2**
Data/parameter:	Crop Type(c)
Description	The type of crop grown on the baseline and treated units during the monitoring period.
Data unit:	N/A (Categorical)
Source of data:	Monitored (Operator records/Remote Sensing)
Purpose of the data	☒ Baseline removals ☒ Activity removals ☒ Leakage emissions (Used for pooling, Table 7)
Measurement and updating frequency	Annually (each monitoring period).
Measurement methods and procedures:	Reported by the farm operator and/or verified via remote sensing data (e.g., USDA Crop Data Layer)
Measuring instrument(s):	N/A
QA/QC procedures:	Data shall be cross-checked against planting records and/or remote sensing data to ensure accuracy.
Comments:	Crop is one of the similarity criteria used to link baseline units to treated units from the project area. Project developers should

	select crop types that satisfy methodology requirements and are suitable for the project geography. It is important for the project developer to assess the time period for SIC generation to occur in microbial inoculant of interest and select a crop with a life cycle longer than that time period.

Parameter ID	**3**
Data/parameter:	Project Area Boundaries and Strata ($Area_i$)
Description	The geographic location and spatial extent (area) of all field sites, baseline units, and treated units (strata) included in the project during the monitoring period.
Data unit:	Hectares (ha); GPS coordinates.
Source of data:	Monitored (GPS/GIS data)
Purpose of the data	☒ Baseline removals ☒ Activity removals
Measurement and updating frequency	Annually (each monitoring period). Shall be updated if new fields are added or boundaries change.
Measurement methods and procedures:	Provided by the project developer using GPS coordinates, shapefiles (.kml), satellite imagery, or maps that clearly delineate the boundaries of each unit.
Measuring instrument(s):	N/A
QA/QC procedures:	Spatial data shall be reviewed to ensure no overlap between units and that all areas are within the defined project boundary and meet applicability criteria.
Comments:	N/A

Parameter ID	**4**
Data/parameter:	Microbial Inoculant Application
Description	Details regarding the application of the microbial inoculant on the treated units.
Data unit:	Date; Application Rate (e.g., liters/ha); Product Name.
Source of data:	Monitored (Operator records)
Purpose of the data	☒ Applicability Criteria ☒ Activity implementation
Measurement and updating frequency	Annually.

Measurement methods and procedures:	Sourced from farm operator records (e.g., as-applied maps, invoices, logs). Used to verify compliance with applicability criteria (once per growing season at planting) and confirm the timing of the monitoring period (Time 0 sampling window).
Measuring instrument(s):	N/A
QA/QC procedures:	Application records shall be reviewed and cross-checked against product purchase records.
Comments:	N/A

Parameter ID	**5**
Data/parameter:	Field Management Practices (Compliance)
Description	Information regarding management practices to ensure compliance with methodology restrictions and any activities that may result in reducing carbon.
Data unit:	N/A (Records)
Source of data:	Monitored (Operator records)
Purpose of the data	☒ Applicability Criteria
Measurement and updating frequency	Annually.
Measurement methods and procedures:	Sourced from farm operator records. Used to verify that: (1) Agricultural limestone or other carbonate materials were not applied (12 months prior or during the season); (2) No changes in management practices that increase GHG emissions (e.g., increased fertilizer use, deeper tilling) have occurred; (3) The land is not irrigated. (4) Activities that result in enhanced reduction of CO_2 is captured appropriately so that the same is reflected in both baseline and project scenarios.
Measuring instrument(s):	N/A
QA/QC procedures:	Management records and operator declarations shall be reviewed.
Comments:	N/A

Parameter ID	**6**
Data/parameter:	Crop Yield Data (Current, Historical, and Regional)
Description	Average yield for crop *c* on the reported field (Ypp,c), historical field yield (Yhp,c), and average regional yield (RYpp,c, RYhp,c).

Data unit:	Tonnes of grain or biomass per hectare (t/ha)
Source of data:	Monitored (Harvest data, Records, Databases)
Purpose of the data	☒ Leakage emissions
Measurement and updating frequency	Annually. Data collection is triggered only if a yield reduction is reported and a leakage assessment is initiated (Section 10.3).
Measurement methods and procedures:	Field-level data (Ypp,c, Yhp,c) sourced from verifiable farm operator records (e.g., yield monitor data, historical logs). Regional data (RYpp,c, RYhp,c) sourced from reputable government statistics (e.g., USDA), industry reports, or international organizations (e.g., FAO).
Measuring instrument(s):	N/A
QA/QC procedures:	Harvest data shall be reviewed for completeness and accuracy. Regional data sources shall be reputable and documented.
Comments:	N/A

Parameter ID	**7**
Data/parameter:	Activity Emissions Data (LCA Approach)
Description	LCA Factor (LCAy): Tonnes of project emissions per tonne of project emissions removals. (Required only if Option 1 is selected in Section 9.2).
Data unit:	Unitless ratio (tCO_2e/tCO_2 removed)
Source of data:	Calculated via Life Cycle Assessment (LCA)
Purpose of the data	☒ Activity emissions
Measurement and updating frequency	Annually (unless minimal components are fixed, see Section 9.2). The underlying LCA study shall be updated at least every three years.
Measurement methods and procedures:	Calculated based on an LCA compliant with ISO 14044 or a similar rigorous standard, encompassing all emission sources (P1, P2, P3, Embodied Emissions) defined in Section 9.1. The LCA shall utilize primary data representative of the actual processes used in the monitoring period.
Measuring instrument(s):	N/A
QA/QC procedures:	If the LCA is performed internally, it shall undergo independent third-party review by a qualified expert. All data sources and assumptions shall be transparently documented and verified.

Comments:	N/A

Parameter ID	**8**
Data/parameter:	Activity Emissions Data (Component-Based Approach)
Description	Data required to calculate emissions from operations (AEop,y), transport (AEtr,y), and embodied emissions (AEem,y). (Required only if Option 2 is selected in Section 9.2).
Data unit:	Various (e.g., kWh, Liters of fuel, kg of material, km traveled)
Source of data:	Monitored (Operational Data/Records)
Purpose of the data	☒ Activity emissions
Measurement and updating frequency	Annually.
Measurement methods and procedures:	Data collected from operational records (e.g., utility bills, fuel purchase invoices, production logs, transport logs, material invoices). Calculations shall follow the relevant Gold Standard or CDM methodological tools referenced in Section 9.3, 9.4 & 9.5. Embodied emissions shall use conservative emission factors from reputable databases (e.g., Ecoinvent).
Measuring instrument(s):	N/A
QA/QC procedures:	Verification of primary data sources (invoices, logs) and cross-checking calculations. Ensure appropriate and up-to-date emission factors (e.g., grid electricity factor) are used. The monitoring plan shall specify exactly which sub-parameters are monitored.
Comments:	N/A

Parameter ID	**17**
Data/parameter:	Soil Organic Carbon (SOC) or Total Organic Carbon (TOC)
Description:	The amount of carbon stored within Soil Organic Matter.
Data unit:	Weight %
Source of data	Directly measured from soil samples
Purpose of the data	☒ Baseline removals ☒ Activity removals ☐ Leakage emissions

Measurement and updating frequency	Twice per growing season: at time 0 (i.e., early-season timepoint) and time t (i.e., late-season timepoint). See Section 15.3 for timing windows.
Measurement methods and procedures:	Measured via laboratory analysis. The preferred method is dry combustion (e.g., using an elemental analyzer). If CCE levels are high, samples shall be pre-treated with acid to remove inorganic carbon before TOC analysis, or SOC must be calculated as the difference between Total Carbon (TC) and SIC. The same procedure shall be used for all samples within a monitoring period.
Measuring instrument(s):	Elemental Analyzer or equivalent. Calibrated according to standards.
QA/QC procedures:	As detailed for Parameter 8 (CCE). Sampling practices shall exclude coarse material (>2cm) from the soil sample analysis. In standard operating procedures, a volume estimate of non-sampled coarse material in the field as well as documentation of >2cm material removed from the sample (either in the field or in the lab) is required and shall be used to correct the volume in addition to bulk density of the sampled material.
Comments:	Used to ensure that SIC gains do not come at the expense of the SOC pool and to quantify the net carbon addition to the soil system.

Parameter ID	**18**
Data/parameter:	Soil bulk density (BD)
Description:	The oven-dry weight of soil per unit of volume for the sampled depth.
Data unit:	g/cm^3
Source of data	Directly measured from soil samples
Purpose of the data	☒ Baseline removals ☒ Activity removals ☐ Leakage emissions
Measurement and updating frequency	Measured during the first monitoring period (Time 0). Re-measurement is required if significant management changes occur that may affect compaction (e.g., change in tillage regime) or at least every 5 years
Measurement methods and procedures:	Shall be measured directly in the field using standardized protocols (e.g., the core method) at the required sampling depth.

	Measurements shall be taken for each stratum. The use of external database values is not permitted.
Measuring instrument(s):	Soil core sampler of known volume, drying oven, calibrated scale.
QA/QC procedures:	Ensure the integrity of the soil core during extraction to maintain the field volume. Samples must be dried to a constant weight (e.g., 105°C) to determine dry mass. Sampling practices shall exclude coarse material (>2cm) from the soil sample analysis. In standard operating procedures, a volume estimate of non-sampled coarse material in the field as well as documentation of >2cm material removed from the sample (either in the field or in the lab) is required and shall be used to correct the volume in addition to bulk density of the sampled material.
Comments:	Critical for converting carbon concentrations (%) to carbon stocks (tonnes/ha).

15.2.2 | Ideally, other measurements can be taken; however, these measurements would not be used as a part of the emissions removal calculations. The suggested analyses are the following: pH (at the late-season timepoint as the early-season timepoint is required), CEC, organic matter, and individual measurement of exchangeable base cations (i.e., calcium, magnesium, potassium, and sodium).

15.3 | Sampling requirements

15.3.1 | A stratified sampling approach shall be used to collect soil samples from both the treated areas and baseline areas to assess SIC and SOC generation. Each field should be stratified based on soil texture. See Parameter ID 1 for acceptable data sources. If other factors (e.g., topography, distinct historical management zones) are known to cause significant variability within the field, these may be used for stratification instead of, or in addition to, soil texture, provided this is justified and documented.

15.3.2 | Random sampling points are defined within each stratum. Appropriate number of sampling points per stratum shall be selected; a minimum of four (4) sampling points per stratum is required. Each sampling point is a soil composite consisting of 5-20 sub-samples or soil cores taken around the center point (i.e., sampling point). For manual sampling, it is recommended to take the sub-samples in a radius of three meters around the center point. See Figure 4 for more details. For automated sampling (e.g., by using utility task vehicles equipped with probes), it is recommended to take the sub-samples in rows next to the center point. See Figure 5 for more details. The sampling points shall be recorded with coordinates, are kept the same throughout the monitoring period (e.g., the growing season), and should remain the same throughout the upcoming years if the same land is used repeatedly. There may be reasons that a sampling point shall be moved at the start of the season or year to year; these cases are acceptable if there is a rationale for the change.

Figure 4: Representation of a manual soil sampling approach of treated and baseline units, sampling points, and sampling events. This methodology is based on a measure-and-remeasure approach.

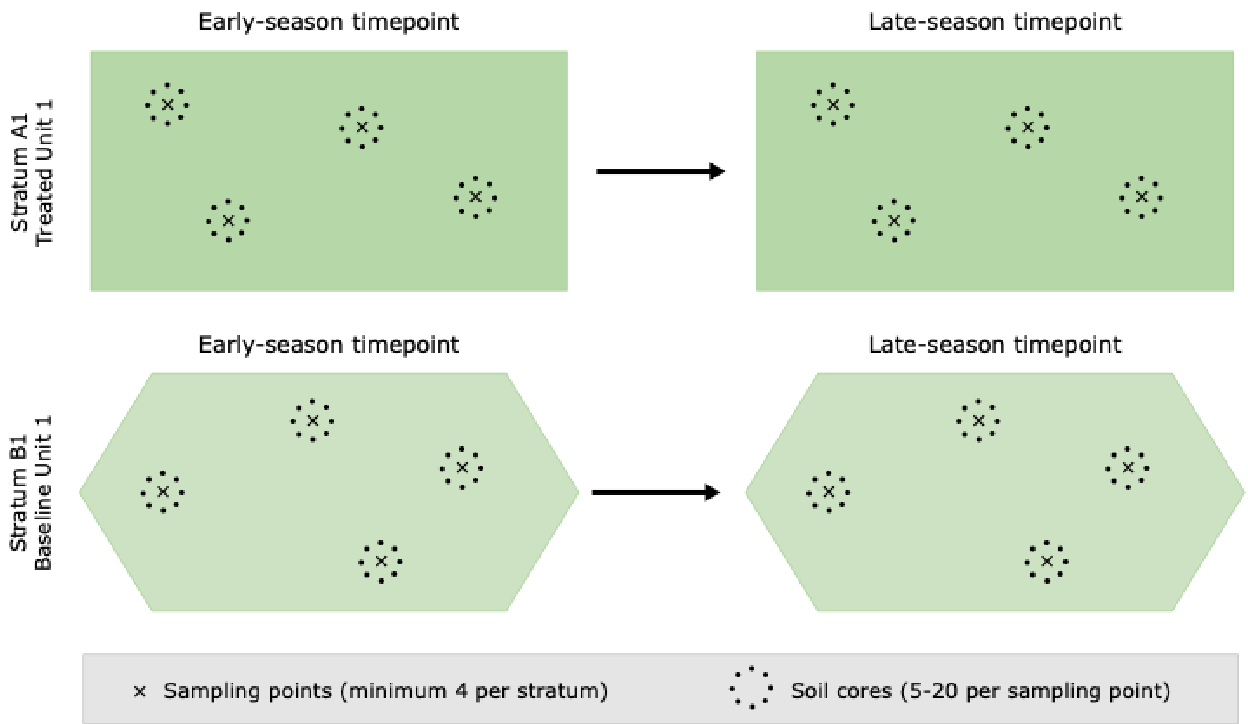
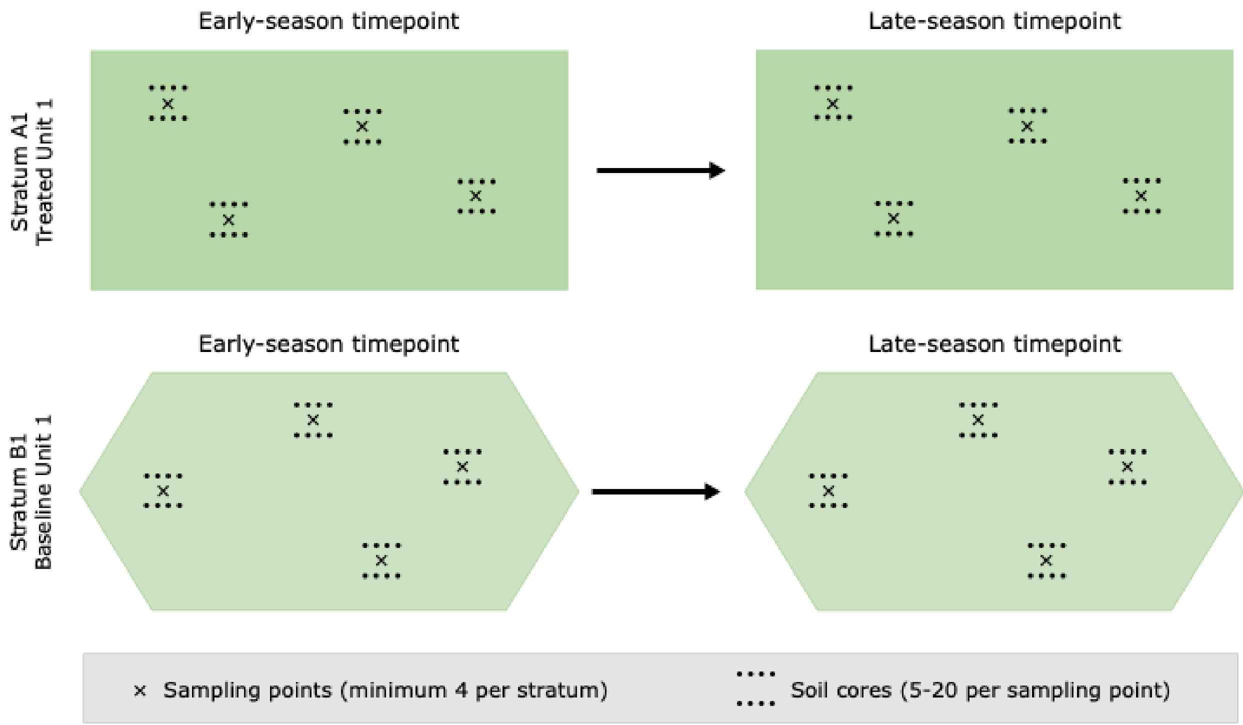


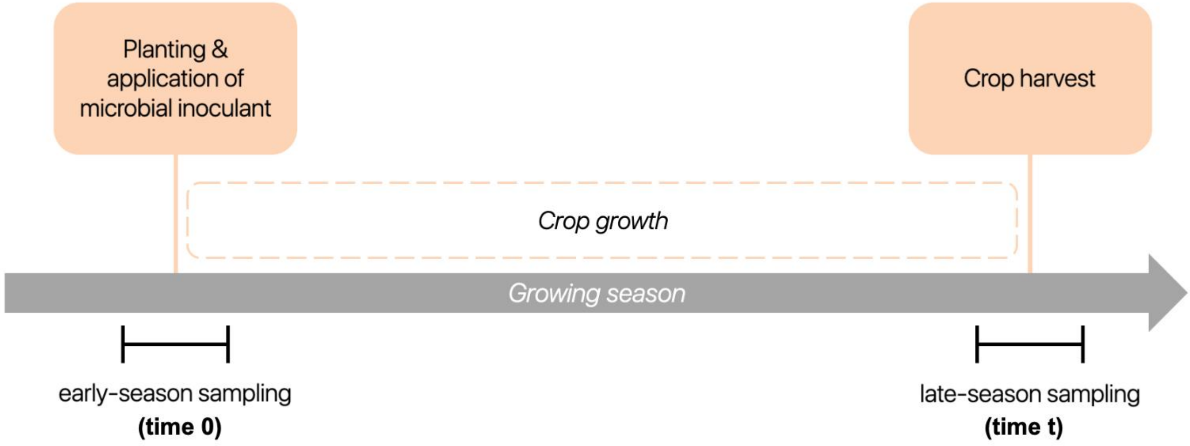
Figure 5: Representation of an automated soil sampling approach of treated and baseline units, sampling points, and sampling events. This methodology is based on a measure-and-remeasure approach.



15.3.3 | The samples (with a soil probe or auger) shall be collected to a minimum depth of 30 cm to measure the SIC signal resulting from the addition of microbial inoculant while minimising potential interference from background SIC already present in the soil. Typically, in topsoils with an existing pool of carbonate compounds, the deeper the soil sampling is performed, the higher the SIC background noise—resulting in a lower signal-to-noise ratio. Projects shall maintain consistent sample depth across all the sample units during the monitoring period.

15.3.4 | For treated and baseline sample units, soil samples shall be collected at a minimum of two different instances (i.e., timepoints) during the growing season. One of the timepoints shall be at the start of the season, referred to as the early-season timepoint or the beginning of the monitoring period (abbreviated as time 0). The early-season timepoint shall be collected within the following time frame: six weeks before microbial inoculant is applied to four weeks after microbial inoculant is applied. Typically, the date the microbial inoculant is applied coincides with planting date. Ideally, the early-season timepoint should be conducted as close to microbial inoculant application/planting as possible. The other time point can be at any time after the early-season timepoint (within eight months) and is referred to as the late-season timepoint (abbreviated as time t). An illustrative diagram is shown in Figure 6.

Figure 6: Illustrative diagram showing the two sampling events or timepoints



15.3.5 | All samples shall be inventoried, labelled, and packaged for shipping to ensure that they are accurately recorded and ready for laboratory analyses and archival preservation.

15.3.6 | Laboratories shall attest to their QA/QC procedures following best practices. QA/QC procedures vary based on the measurement method and shall be discussed in detail in the project design document.

15.3.7 | To ensure that samples can be analysed and re-tested in the future, if necessary, it is important to collect a sufficient volume of each sample (e.g., 0.5 kg). Best practice is splitting this sample into two bags, with one sent for analysis and the other sent for storage for future re-testing, if necessary. All samples shall be dried and ground (less than or equal to 2 mm) for storage in an archive. The samples can be stored in-house, or arrangements can be made with an external laboratory to create an archive. Archived samples should be completely dried or frozen to prevent ongoing biological activity from changing soil carbon densities and to stop ongoing chemical reactions. Samples shall be stored for a minimum of two years after credit verification.

15.3.8 | Soil sampling shall follow established best practices, such as those found in the USDA GRACE net Sampling Protocol, Chapter 1 (Liebig et al., 2010).

15.3.9 | Statistical Requirements for Pooling To ensure sufficient statistical power for the analysis is described in Section 11.4, each treated unit pool (tu_p) and baseline unit pool (bu_p) must contain a minimum number of units (strata).

a. Minimum Units per Pool: Each pool (tup and bup) shall contain data from at least five (5) distinct units.

b. If a pool does not meet this minimum requirement, it shall be excluded from the calculation of Activity Removals (ARy).

16| APPLICATION TO PROGRAMME OF ACTIVITIES

16.1.1 | The methodology may be applied for standalone activities or a program of activities (PoAs). In the latter case, the technology provider(s) may act as

Coordinating and Managing Entity (CME). For inclusion of a Voluntary Project Activity (VPA) to the PoA, the inclusion criteria shall be designed following the methodology requirements and other applicable Gold Standard requirements.

17| RENEWAL OF CREDITING PERIOD

17.1.1 | At the time of renewal of crediting period, the project shall:

a. Reassess the continued validity of the baseline scenario in line with any changes in the relevant national and/or sectoral regulations and incorporate the impact of new regulations on baseline.
b. Update the baseline emissions using the new data available, where needed.
c. Update the ex-ante parameters value (any not updated during the crediting period).
d. Incorporate any relevant updates to the GS4GG requirements as applicable to the project activity.

17.1.2 | For renewal of the crediting period, the project shall apply the latest available version of the methodology.

18| REFERENCE

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ANNEX 01: ANALYSIS OF LOCK-IN RISK - METHODOLOGY-LEVEL

1. Introduction and Scope

This annex presents the analysis of the risk that activities implemented under the methodology "Microbial Carbon Mineralization (MCM)" may lead to locking in levels of emissions, technologies, or carbon-intensive practices incompatible with the long-term goals of the Paris Agreement.

This analysis is conducted at the methodology level by the methodology developer, in accordance with Section 6.2 of the GS4GG *Standard: REQUIREMENTS FOR ADDITIONALITY DEMONSTRATION* (Version 01.0).

2. Overview of the Technology and Practice

The MCM methodology applies to activities that remove CO_2 by applying a microbial inoculant to existing cropland, converting atmospheric CO_2 into durable Soil Inorganic Carbon (SIC).

Key characteristics relevant to the lock-in risk analysis include:

- **Implementation:** The practice involves the application of the inoculant typically once per growing season at the time of planting.
- **Infrastructure:** The activity utilizes standard agricultural equipment and does not require the installation of new, specialized, or long-lived infrastructure.
- **Flexibility:** Farm operators retain the flexibility to discontinue the use of the inoculant or change management practices on a seasonal basis.

3. Risk Identification and Analysis

The assessment of lock-in risk is based on the criteria outlined in Section 6.2 of the GS4GG *Standard: REQUIREMENTS FOR ADDITIONALITY DEMONSTRATION* (Version 01.0).

3.1. Technical and Operational Lifetime (Para 6.2.2 (a) & (c))

The analysis must consider the technical or operational lifetime of the technologies or practices established as part of project activity.

- **Technology Lifetime:** The microbial inoculant is a consumable input that is utilized during the growing season. It is not a long-lived physical asset.
- **Operational Lifetime of Practice:** The practice is the application of the inoculant. Decisions regarding agricultural inputs are made by farm operators on an annual or seasonal basis. As there is no infrastructural investment or path dependency created that commits the operator to the practice beyond the current growing season, the operational lifetime of the practice is determined to be one year.

3.2. Application of the Short Lifetime Provision (Para 6.2.2 (c))

As justified in section 3.1, the operational lifetime of the practice is one year, which is significantly less than the 10-year threshold. Therefore, based on the evidence provided, this methodology assumes that **no lock-in risk exists** for eligible activities.

Methodology Validity Limitation:

In accordance with the requirements of Paragraph 6.2.2. (c), as this provision is utilized: "the validity of the methodology shall be limited 31st Dec 2030 and the methodology shall be reviewed by the Secretariat prior to its expiry."

3.3. Supplementary Analysis of Compatibility and Efficiency

Although the short lifetime provision (Para 6.2.2.) is applied, the following analysis confirms the methodology's alignment with the core criteria of Paragraph.

a. Compatibility with Long-Term Goals and GHG Intensity (Para 6.2.2. (b)

The activity is a Carbon Dioxide Removal (CDR) pathway, resulting in net GHG removals (negative emissions intensity). This is inherently compatible with the long-term goals of the Paris Agreement. All material activity emissions are accounted for via a required Life Cycle Assessment (LCA) within the methodology. Furthermore, the methodology explicitly prohibits changes in field management practices that could lead to increased GHG emissions (e.g., increased synthetic fertiliser application, deeper tilling).

b. Efficient Use of Resources (Para 6.2.2. (d))

The methodology includes requirements to ensure the activity does not constitute an inefficient use of resources critical for mitigating climate change or achieving other policy objectives (e.g., food security, water availability):

- **Water Resources:** The Applicability Criteria explicitly exclude irrigated land, minimizing competition for critical water resources.
- **Land Use and Food Security:** The activity is restricted to existing cropland. The methodology includes rigorous procedures (Section 10, Leakage emissions) to monitor agricultural productivity. If a yield reduction greater than 5% attributable to the project is observed, the emission removals for the affected field(s) are entirely discounted. This ensures efficient land use by maintaining agricultural outputs alongside CDR.

c. Availability of Alternatives (Para 31(d))

The short operational lifetime and lack of infrastructure investment ensure that no path dependencies are created. The activity does not prevent the adoption of alternative sustainable practices or superior CDR technologies in the future.

4. Mitigation Measures Adopted in the Methodology

The design of the methodology inherently mitigates lock-in risks through the following key features:

1. **Short Operational Commitment:** Annual application cycle allowing for seasonal decision-making and adaptability.
2. **No Long-Lived Infrastructure:** Utilization of existing agricultural systems and equipment.
3. **Resource Safeguards:** Exclusion of irrigated land and requirement to maintain agricultural productivity.
4. **Prohibition of High-Emission Practices:** Explicit exclusion of management changes that increase associated GHG emissions.

5. Conclusion and Project-Level Requirements

a. Conclusion:

   The methodology-level analysis concludes that activities implemented under the MCM Methodology present no risk of locking in levels of emissions, technologies, or carbon-intensive practices. This conclusion is based on the justification that the operational lifetime of the practice is one year, meeting the criteria for assuming no lock-in risk in accordance with Section 6.2 of the GS4GG *Standard: REQUIREMENTS FOR ADDITIONALITY DEMONSTRATION* (Version 01.0).

b. Project-Level Requirements:

   As the lock-in risk is deemed non-existent at the methodology level based on the short operational lifetime, no specific project-level requirements for the assessment, monitoring, or verification of lock-in risks are necessary. Activity participants shall ensure ongoing compliance with the methodology's applicability criteria, which shall be assessed during validation and verification.

ANNEX 02: COMMON PRACTICE ANALYSIS: METHODOLOGY-LEVEL

This annex presents a methodology-level Common Practice Analysis for the "Microbial Carbon Mineralization" methodology, conducted in accordance with the procedures outlined in the GS4GG "Methodological Tool: Common Practice Analysis" (the Tool). This analysis utilizes the provision for assessment at the methodology level (Tool Section 5.3).

1. Standardized Parameters and Scope

This analysis evaluates the global market penetration of applying microbial inoculants for the explicit purpose of enhancing Soil Inorganic Carbon (SIC) mineralization as a Carbon Dioxide Removal (CDR) strategy.

(A) Applicable Geographical Area (AGA) (Tool Sec. 7.2)

- **AGA:** Global.
- **Geographical Classification:** Other Countries (applied as the conservative default for a global analysis).
- **Justification:** The methodology is designed for global applicability across various crops and climate zones; therefore, the methodology-level analysis is conducted at a global scale.

(B) Indicator (P) and Assessment Approach (Tool Sec. 7.5)

- **Indicator (P):** Capacity/Output-based.
- **Metric:** Hectares (ha) of cropland under management.
- **Assessment Approach:** Stock-Based.
- **Justification for Approach:** The activity involves the application of an inoculant as a land management practice. The cumulative area (Stock) adopting the practice in a given cropping season is the most relevant and stable measure of prevalence for agricultural activities (Tool Sec 7.5.3).
- **Reference Point:** The analysis utilizes the most recent comprehensive global agricultural statistics available at the time of assessment (FAO, 2021).

2. Determination of Target Market Size (Pall) (Tool Sec. 7.3)

- **Definition:** P_{all} is the total area (ha) of existing cropland globally that meets the methodology's core technical applicability criteria. The methodology excludes wetlands, grasslands, forests, and irrigated land.
- **Calculation:** The Target Market Size is calculated using data from the Food and Agriculture Organization of the United Nations (FAOSTAT).
    - Total Global Cropland (Arable land and Permanent crops) (2021): 1,580 Mha (FAO, 2021).

- Less Global Area Equipped for Irrigation (2021): 352 Mha (FAO, 2021).

- **P_{all}:** 1,228 Mha (1,228,000,000 ha).
- **Conservativeness Note:** The methodology also requires an average soil pH equal to or higher than 6.3. Due to the unavailability of precise global datasets that intersect non-irrigated cropland area with soil pH levels, this constraint is excluded from the Pall calculation. This omission results in an overestimation of the Target Market Size, making the subsequent penetration analysis conservative.

3. Determination of Similar Activities (Psim) (Tool Sec. 7.4)

- **Definition:** P_{sim} is the total area (ha) within the Target Market (Pall) where practices matching the Attribute Matrix below are implemented *autonomously* (i.e., without reliance on carbon revenue, Tool Sec 5.2).

Attribute Matrix for Microbial Carbon Mineralization (SIC) Similarity

Attribute	Description	Required for Similarity (Yes/No)
Land Use Type	Existing Cropland (meeting applicability criteria: non-irrigated, non-wetland).	Yes
Technology/ Practice	Application of microbial inoculants (non-GMO).	Yes
Purpose/ Mechanism	Inoculant specifically intended and applied to increase Soil Inorganic Carbon (SIC) via mineralization for CO_2 removal.	Yes
Scale	Hectares under management or farm size.	No

- **Market Analysis:**
  - Microbial inoculants (e.g., biofertilizers, biostimulants) are utilized globally primarily for enhancing crop nutrition, improving plant health, and environmental sustainability (Aloo et al., 2019; Saxena et al., 2020). Some applications may also aim to increase Soil Organic Carbon (SOC) (Just et al., 2024).
  - However, the application of inoculants specifically to drive carbon *mineralization* (the formation of durable SIC) as a CDR pathway is a distinct and novel approach (Manning, 2008).
  - The scientific literature indicates that microbial mineralization has not been widely adopted for SIC enhancement due to significant scientific, technical, and practical limitations. The efficiency of microbial processes in significantly increasing SIC is constrained by environmental factors, and manipulating soil microbial communities at scale is complex (Zhu & Dittrich, 2016). Natural

rates of microbial-induced carbonate precipitation are often slow and highly variable, posing challenges to achieving measurable and scalable SIC gains within practical timeframes (Mitchell et al., 2010). The dynamics of SIC in response to management changes are also complex (Li et al., 2018).

  - Due to these complexities, microbial mineralization remains a niche approach compared to other soil carbon strategies (Lal, 2019). Recent research identifies harnessing microbes for CDR via this pathway as an emerging technology (Timmermann et al., 2025).

- **Exclusion of Carbon Revenue Activities:** Known pioneering deployments utilizing this specific pathway (e.g., Andes, 2024) are explicitly driven by the intent to validate the CDR pathway and generate carbon revenue. In accordance with Tool Sec 5.2, these activities must be excluded from Psim, as they do not represent autonomous market adoption.
- **P_{sim}:** Based on the analysis of current agricultural practices and the scientific literature, there is no evidence of autonomous adoption of this specific practice globally. Therefore, Psim = 0 ha.

4. Determination of Common Practice Threshold (Fmax) (Tool Sec. 7.6)

- **Technology Maturity Category (TMC):** TMC-1 (Innovator/Nascent).
- **Justification:** The utilization of microbial inoculants specifically optimized for durable SIC mineralization qualifies as a nascent CDR strategy (TMC-1). It has zero autonomous market presence (Psim = 0 ha). The significant scientific and technical barriers identified (Lal, 2019; Zhu & Dittrich, 2016) confirm that commercial viability and scalability are currently dependent on the development of carbon markets.
- **Fmax (Stock-Based, TMC-1, Other Countries):** 2.5% (Tool Table 2).

5. Calculation and Conclusion

Calculate the Common Practice Factor (F) (Tool Sec. 6.4)

F = Psim / Pall

F = 0 ha / 1,228,000,000 ha

F = 0%

Compare F with Fmax (Tool Sec. 6.5)

F (0%) < Fmax (2.5%)

Conclusion:

The Common Practice Factor (F) is zero, which is significantly below the Common Practice Threshold (Fmax). Therefore, the activity of utilizing microbial inoculants for Soil Inorganic Carbon mineralization is not common practice.

6. Validity and Application

Projects that meet the applicability conditions of this methodology are exempt from conducting a project-level common practice analysis (Tool Sec 5.3.3).

Validity Period: This methodology-level analysis is valid for three (3) years from the date of this methodology's publication of V 1.0 (Tool Sec 5.3.2).

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