PM.0002

Adoption of low-emission fertilizer strategies to transition to low-carbon agriculture

GHG Methodology
Version 1.0

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Methodology:

Adoption of low-emission fertilizer strategies to transition to low-carbon agriculture

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List of definitions

Additionality	Refers to the concept that any GHG project should result in greenhouse gas emissions mitigation (GHG reductions or removals) that would not have occurred without the project. In other words, the project's positive impact on reducing or removing emissions should be "additional" to what would have happened under the baseline scenario.
Ammonia volatilization	The process by which ammonia (NH_3) gas is released into the atmosphere from ammonium-containing fertilizers (e.g., urea). This can lead to indirect GHG emissions when ammonia is subsequently converted to nitrous oxide (N_2O) in the environment.
Baseline scenario	The baseline scenario represents the emissions that would occur based on the business as usual agricultural management practices. In other words, this includes fertilizer management and other relevant activities, without the use of low-emission fertilizers.
Buffer pool	A Buffer Pool is a shared reserve of Carbon Credits established to cover potential losses in GHG Projects, ensuring the integrity of emission reductions or removals over time. Each GHG Project contributes to Proba's Buffer Pool when Carbon Credits are being issued. These Carbon Credits can only be used by Proba to compensate for reversals.
Carbon credit (emission reduction certificate)	A carbon credit represents at least 1 tonne of CO2 (tCO_2), or 1 tonne of CO2e (tCO2e) reduced or removed for a certain period of time. One tonne (metric ton) (t) equals 1000 kg. For carbon equivalency, Proba uses the AR-5 assessment from UNFCCC[1].
Carbon dioxide equivalent - CO_2e	A metric used to compare the emissions of various greenhouse gases based on their Global Warming Potential (see GWP definition). It expresses the impact of different gases in terms of the equivalent amount of CO2, facilitating a standardized approach to assessing overall greenhouse gas emissions.
Conservativeness	When there is uncertainty or a choice between two or more assumptions, values, methodologies, or procedures, the option that is more likely to result in lower estimates of GHG emission reductions or removals must be selected. This approach ensures that claimed climate benefits are not overestimated.
Controlled-release fertilizers (CRFs)	Slow- or controlled-release fertilizer is defined as a fertilizer containing a plant nutrient in a form which delays its availability for plant uptake and use after application, or which extends its availability to the plant significantly longer than a reference 'rapidly

[1] https://ghgprotocol.org/sites/default/files/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_0.pdf

	available nutrient fertilizer' such as ammonium nitrate or urea, ammonium phosphate or potassium chloride. Such delay of initial availability or extended time of continued availability may occur by a variety of mechanisms. These include controlled water solubility of the material by semi-permeable coatings, occlusion, protein materials, or other chemical forms, by slow hydrolysis of water-soluble low molecular weight compounds, or by other unknown means. Definition based on Trenkel (2010).
Cradle-to-gate	A life cycle assessment boundary that includes all greenhouse gas emissions associated with a product's life cycle stages up to the point it reaches the project's location. This includes emissions from raw material extraction, production, and transportation to the project's location. It excludes emissions from field application or any subsequent stages beyond the project's location.
Crediting period	The "crediting period" refers to the specific duration of time during which a GHG project is eligible to generate and issue emission reduction certificates for the GHG emissions it reduces or removes. This period is predefined and ensures that the project's emissions impact is monitored, verified, and credited only within that set timeframe. A crediting period can be renewed once or multiple times.
Crops	In the context of this methodology, "crops" refers to all cultivated plant products that receive fertilizer application. This includes cereals, vegetables, fruits, legumes, flowers, forage crops (e.g., grasses for animal feed), and industrial crops. The term is used inclusively to reflect the wide applicability of fertilizer interventions across agricultural systems
Emission factors	Emission factors are coefficients that quantify the amount of greenhouse gases released into the atmosphere per unit of activity, substance, or process. They are essential tools in calculating emissions and facilitating the estimation of a project's total greenhouse gas emissions. The Intergovernmental Panel on Climate Change (IPCC) has established a three-tier system for the development and application of emission factors (Tier 1, Tier 2, and Tier 3). These tiers are presented in appendix A.1 Tier definitions.
Fugitive emissions	Unintended releases of gases or vapors from pressurized equipment due to leaks, equipment malfunctions, or other unforeseen incidents. In fertilizer production, common sources include, but are not limited to, valves, joints, seals, and storage tanks.
GHG project	Activity or activities that alter the conditions of a GHG Baseline and which cause GHG emissions reductions or GHG removals. The intent of a GHG project is to convert the GHG impact into emission reduction certificates.

Global Warming Potential (GWP)	The time-integrated radiative forcing resulting from a pulse emission of a specific greenhouse gas, relative to the radiative forcing from a pulse emission of an equivalent mass of carbon dioxide (CO_2) (Woolf et al., 2021). It provides a common scale to compare the climate impact of different gases over a specific time horizon, typically 100 years. This methodology allows the AR6 values [2].
Greenfield facility	A project where a new facility is built from the ground up on undeveloped land, where no previous building or infrastructure existed that served the same purpose.
Inorganic fertilizers	Fertilizers manufactured through chemical processes or mined from natural deposits and then processed to be concentrated and standardized. These include: nitrogen fertilizers (e.g., urea, ammonium nitrate), phosphorus fertilizers (e.g., superphosphate), potassium fertilizers (e.g., potassium chloride). They are typically water-soluble and immediately available to plants, which makes them highly efficient but also potentially leachable.
Insetting	Insetting refers to the practice of implementing sustainability interventions within a company's own value chain to reduce greenhouse gas (GHG) emissions or enhance carbon sequestration. Unlike offsetting, which typically involves purchasing carbon credits for activities outside the value chain, insetting focuses on reducing emissions directly linked to the company's operations, suppliers, or production processes.
Inventory-Based Accounting	A GHG accounting approach that measures and reports emissions at a broader scale, such as a company's value chain, a sector, or a geographic area, over a set period, typically in line with Scope 1, 2, and 3 categories. In this approach, for emission reductions to be attributed, there must be a verifiable connection between the demand (e.g., a buyer's procurement choices) and the supply shed (the defined set of suppliers or production regions whose practices are being improved). This ensures that reported impacts are directly linked to the actual sources from which goods or services are sourced.
IPCC	The Intergovernmental Panel on Climate Change is a United Nations body, assessing science related to climate change to provide policymakers with regular scientific updates.
Land Management Unit (LMU) / Field level	A Land Management Unit (LMU) is a clearly defined area of land under consistent management, where fertilizer application can be directly monitored and attributed. The LMU level allows GHG emissions and reductions to be accurately measured and linked to specific land parcels, each with defined boundaries and documented management practices. It is aligned with the GHG Protocol's *Land Sector and Removals Guidance* definition [3].

[2] https://ghgprotocol.org/sites/default/files/2024-08/Global-Warming-Potential-Values%20%28August%202024%29.pdf
[3] https://ghgprotocol.org/land-sector-and-removals-guidance

Leakage	In the context of a GHG project, leakage refers to the unintended increase in greenhouse gas emissions outside the project boundaries as a direct result of the project's activities.
Low-emission fertilizer	In this document, *low-emission fertilizer (technology)* refers to an inorganic or organic fertilizer that demonstrably reduces greenhouse gas emissions compared to conventional baseline fertilizers, either through a lower Product Carbon Footprint (PCF) from production, a reduced in-field emission factor (EF), or the ability to achieve equivalent productivity at a lower nutrient application rate.
Nitrate leaching	The vertical movement of nitrate through soil profile into deep layers along with irrigation water or rainfall. This process can lead to groundwater contamination (e.g., because nutrients and cations can be leached). and the indirect emission of nitrous oxide (N_2O) when nitrates are converted by microbial activity in anaerobic conditions.
Nitrogen stabilizer	Nitrogen stabilizers are compounds incorporated into fertilizer products that are used in agriculture to prolong the availability of nitrogen in soil, thereby improving its efficiency. These stabilizers typically work by inhibiting the conversion of ammonium to nitrate, reducing nitrogen loss through leaching and denitrification. (e.g., nitrification inhibitors, urease inhibitors, or a combination of both)
Nitrogen stabilizers mixtures	Fertilizers mixed with nitrogen stabilizers before application, either at the field level or through distribution channels.
Nitrogen Use Efficiency (NUE)	Nitrogen use efficiency refers to the effectiveness with which crops utilize applied nitrogen for growth and yield. It can be defined as biomass production (or crop yield) per unit of nitrogen applied to the crop.
Nut-rate	In this methodology, the application rate is defined in terms of nutrient applied (not just nitrogen), to account for cases where the low-emission fertilizer reduces emissions associated with any of the primary nutrients: nitrogen (N), phosphorus (P), or potassium (K).
Nutrient Use Efficiency (NutUE)	Nutrient use efficiency refers to the effectiveness with which crops utilize applied nutrients (NPK) for growth and yield. It can be defined as biomass production (or crop yield) per unit of nutrient applied to the crop.
Offsetting	Offsetting refers to the practice of compensating for greenhouse gas (GHG) emissions by supporting projects outside a company's value chain that reduce or remove emissions. This is typically achieved by purchasing carbon credits from verified initiatives.
Organic fertilizer	Fertilizer products containing organic carbon and nutrients of solely biological origin and excluding materials which are fossilized or embedded in geological formations.

	Note: Organic fertilizers are different from fertilizers authorized in organic farming, which may include some mineral fertilizers such as phosphate rock.
Proba Standard	The Proba Standard aims at controlling and reducing the risks related to GHG projects, their climate impact (emission reduction) and the corresponding issuance of emission reduction certificates and subsequent claims. It does so by relying on and aligning with internationally recognized standards frameworks and initiatives such as the Core Carbon Principles by the ICVCM and the ICROA Code of Best Practice. The Proba Standard sets out detailed procedures for identification and validation of GHG projects, and verification of emission reductions and removals, based on ISO 14064-2. More information about the Proba Standard can be found at https://proba.earth/document-library.
Product Carbon Footprint (PCF)	Sum of GHG emissions and GHG removals in a product system, expressed as CO_2 equivalents and based on a life cycle assessment using the single impact category of climate change (definition based on ISO 14067:2018)
Project boundaries	The project boundaries of a GHG project delineate the spatial, temporal, and operational limits within which the GHG emissions, reductions, and removals are quantified and monitored, encompassing specific activities, sources, sinks, and reservoirs related to the project.
Project Overview Document (POD)	A document that offers a detailed summary of a GHG project's key elements, including governance, emission calculations, risk management, methodologies, and monitoring processes (see Proba Standard).
Project-Based Accounting	A greenhouse gas (GHG) accounting approach that quantifies emission reductions or removals from a clearly defined project or intervention. The accounting boundary focuses on the specific activities, locations, and time period of the project, with baselines and monitoring focused on those parameters. Results are typically expressed in terms of avoided or removed emissions relative to a baseline scenario.
Runoff	The horizontal movement of water across the soil surface, carrying with it dissolved and particulate nutrients from fertilizers as well as (fine) soil particles to nearby water bodies. Runoff can result in surface water pollution and contribute to eutrophication. Additionally, when nitrogen compounds in runoff reach water bodies, they can undergo microbial activities which result in indirect emissions of nitrous oxide (N_2O).
Sourcing Region	A geographically distinct area characterized by common environmental, climatic, and land use conditions. It may encompass

	an entire country, a jurisdiction, or a specific part of it, and is typically defined by administrative boundaries, agroecological zones, or sourcing areas. It is aligned with the GHG Protocol's *Land Sector and Removals Guidance* definition [4].
Tier 1, 2 and 3	In the context of greenhouse gas (GHG) emissions reporting and inventory management, data and methodologies are categorized into three tiers (Tier 1, Tier 2, and Tier 3), as defined by the Intergovernmental Panel on Climate Change (IPCC). These tiers represent varying levels of accuracy, data specificity, and complexity. For more information see appendix A.1 Tier definitions.
Verification and Validation Bodies (VVBs)	Third-party assurance entities, preferably ISO-accredited, are responsible for verifying that a project's activities and claims of emissions reductions and/or removals are conducted in accordance with established standards and methodologies, ensuring their accuracy and credibility.

[4] https://ghgprotocol.org/land-sector-and-removals-guidance

List of abbreviations

AR6	IPCC Sixth Assessment Report
EF	Emission Factor
GHG	Greenhouse Gas
IFA	International Fertilizer Association
IPCC	Intergovernmental Panel on Climate Change
LCA	Life Cycle Assessment
LMU	Land Management Unit level
MRV	Monitoring, Reporting, and Verification
N_2O	Nitrous Oxide
NH_3	Ammonia
NO	Nitric oxide
NO_2^-	Nitrite
NO_3^-	Nitrate
NUE	Nitrogen Use Efficiency
NutUE	Nutrient Use Efficiency
PCF	Product Carbon Footprint
POD	Project Overview Document
SDG	Sustainable Development Goal
T&D	Transmission and distribution
VVB	Verification and Validation Body

1. Introduction

1.1 Background

Fertilizer production has traditionally been energy-intensive, relying heavily on fossil fuels which contribute significantly to global greenhouse gas (GHG) emissions. This conventional production method not only requires high energy inputs but also releases substantial amounts of CO_2 and other GHGs during its production processes. For instance, the production and usage of nitrogen fertilizers account for approximately 5% of global greenhouse gas (GHG) emissions [5]. In addition to emissions from production, fertilizer use also contributes significantly to agricultural GHG emissions through soil-based processes, particularly nitrous oxide (N_2O) emissions following field application. As such, the development of more sustainable practices and technologies in the field of fertilizer production and application is a critical area of focus for reducing the agricultural sector's environmental impact. Addressing emissions across the full fertilizer lifecycle (from manufacturing to field-level use) requires a transition toward lower-emission nutrient management strategies that reduce both the product carbon footprint and the emissions arising from fertilization practices on the field.

1.2 Applicability of methodology

- This methodology applies globally to interventions that reduce GHG emissions associated with fertilizer production and/or application through the adoption of low-emission fertilizer technologies in managed soils [6]. These interventions (which may be combined) include:
    1. Fertilizer production emissions reduction: The introduction of (inorganic or organic) fertilizers that come with a lower Product Carbon Footprint (PCF) as a partial or full replacement of conventional fertilizers
    2. Fertilizer in-field emissions reduction: The introduction of fertilizers that can demonstrably lead to a reduction of in-field emissions (direct or indirect N_2O) compared to the baseline fertilization. This can be achieved both by:
        - b.i. EF related: fertilizers that have a reduced in-field emission factor (EF) compared to the baseline fertilization
        - b.ii. Nut-rate related: fertilizers that can be applied with a reduced nutrient application rate (Nut-rate) compared to the baseline and thus lead to a reduction of in-field emissions. This includes cases where a reduction in total

[5] https://www.nature.com/articles/s43016-023-00698-w#
[6] Soils where human activities influence their use or condition, such as agricultural fields, pastures, plantations, or other lands where nutrient application or other management practices are carried out.

nutrient input is achieved through more efficient delivery mechanisms or the use of complementary nutrient sources (e.g., blending of mineral and foliar fertilizers, or inclusion of organic nutrient sources), provided that equivalence in productivity is maintained (this is assessed through the second leakage test, see section 1.8. Leakage & permanence). This type of intervention is only applicable under the Land Management Unit type of projects (see section 2.3 Spatial boundaries), as traceability of the reduction of the Nut-rate must be possible. Moreover, to make sure that such projects demonstrably lead to maintained crop yields, they must commit for a crediting period of at least 3 years for annual and perennial crops and 4 years for biennial crops.

- Project developers must be able to prove that the intervention leads to an actual replacement of high-emission conventional fertilizers on the spatial level of their project (see section 2.3 Spatial boundaries). This is done by defining the baseline fertilizer product, as described in section 3. Baseline scenario.
- Each of the two intervention types has its own requirements. Project developers must address the specific aspects applicable to the intervention type(s) relevant to their project.
    1. Fertilizer production emissions reduction
        - For both the baseline and intervention, project developers must provide evidence of the product carbon footprint (PCF) related to the fertilizers in scope. More information on the evidence that must be sourced can be found on section 4.1 EF-data reference approaches.
        - This methodology allows for partial substitution of conventional fertilizers, where only specific nutrient components (e.g., nitrogen in an NPK fertilizer) or a portion of a specific nutrient component is replaced with a low-emission (PCF related) alternative while others remain unchanged. Emission reductions are calculated only for the substituted component, ensuring accurate impact attribution.
        - Project developers must provide evidence of nutrient composition, agronomic equivalence to the substituted nutrient(s), and ensure transparent calculation of emissions reductions specific to the replaced fraction.
    b. Fertilizer in-field emissions reduction (general, including both *b.i.* and *b.ii.*)
        - Project developers must provide verifiable evidence that the introduced low-emissions fertilizer technology serves as a viable substitute for the conventional high-emission fertilizer in terms of agronomic effectiveness. For that purpose, scientific studies or verifiable field studies must be used.

In either case, the quality criteria presented in the appendix A.2.3 Quality criteria of experimental design (of studies/trials) must be followed.

- For both the **baseline** and **intervention**, project developers must provide scientific proof of the emission factors (EFs) related to the specific characteristics and activities of the project.
  - This scientific proof must be sourced from one of the following: 1) a relevant meta-analysis, or 2) original scientific literature.
  - The EFs used must be retrieved from studies that meet specific quality criteria, and project developers must demonstrate that the characteristics and activities of both the baseline and intervention are consistent with the key environmental factors and management practices described in the supporting scientific evidence (see appendix A.2.1 Alignment with the key environmental factors and management practices).
  - For sourcing region type of projects, a context specific emission factor (Tier 2 - type [7]), derived from aggregated product-specific EFs, must be used.
  - In cases where there is no supporting scientific evidence of the impact of the fertilizer technology on the GHG emissions related to specific crops, cropping systems, and agroecologies, an aggregated EF reduction impact can be used from a meta-analysis. The procedure of selecting an appropriate value is described in section 4.3 Uncertainty and must be properly justified and documented.
- Project developers must demonstrate that baseline and project nutrient inputs are applied at appropriate rates based on regional agronomic guidelines or best practices. This ensures that the baseline and project fertilization is not excessive and avoids rewarding projects that apply nutrients beyond typical regional norms, which could otherwise inflate emission reductions linked to the improved NutUE. Where regional baseline fertilization is excessive, project developers must clearly disclose this and structure their projects to support improved, agronomically appropriate nutrient application rates. For this purpose, project developers must do a *NutUE Performance Test*, as defined in section 3. Baseline Scenario.

- This methodology is applicable to projects that introduce changes to management practices on top of the usage of low-emission fertilizer technologies (e.g., adopting improved tillage methods, introducing cover crops, or similar), if another relevant GHG

[7] Explanation of the Tier approach can be seen in the appendix A.1 Tier definitions

methodology is used, which ensures that the additional emission reductions are quantified, verified and accounted for accurately and transparently. This is only applicable for Land Management Unit spatial level type of projects, where these types of interventions can be tracked and verified.

- This methodology can work **synergistically** with other GHG methodologies or programs that target emissions reductions or removals in areas outside the scope of this methodology. For instance, a program could combine the introduction of low-emission fertilizers with the application of nitrogen stabilizers, thereby achieving complementary climate benefits while ensuring that the integrity of the emission reductions from activities under this methodology is maintained. Two examples of GHG methodologies that can be used include:
    1. PM.0005: Adoption of controlled-release fertilizers to transition to low-emission agriculture [8]
    2. PM.0004: Adoption of nitrogen stabilizers to transition to low-emission agriculture [9]
- In case this methodology is used in conjunction with other methodologies or programs then the project developer must:
    1. explicitly mention that in the POD and
    2. demonstrate that benefits are not quantified more than once (to mitigate the risk of double counting the impact of nitrogen stabilizers across two projects)
    3. provide a separate monitoring framework to ensure that combined interventions do not undermine each other's effectiveness in long-term consistency
- Project developers must report any changes in fertilizer formulations or suppliers that affect emission factors or nutrient efficiency through the monitoring framework (section 6. Monitoring, Reporting and Verification) and must be transparently reported and justified in the verification report.
- Project developers must be transparent and report on additional activities that happen along with or because of the introduction of low-emission fertilizer technologies, which can lead to material changes of emissions on the field. Some (non-exhaustive) examples of such activities:
    1. Switching from low-emission fuel to high-emission fuel for field operations
    2. Introducing nitrogen stabilizers
    3. Adding irrigation events that consume energy or water
- Project developers must ensure that the applicability, eligibility and additionality criteria presented in this methodology are fulfilled.
- This methodology can be used for both offsetting and insetting projects. In alignment with emerging SBTi guidance, insetting projects should prioritize direct mitigation, where the

[8] https://proba.earth/crf_methodology
[9] https://proba.earth/nitrogen_stabilizers_methodology

intervention can be physically linked to specific emissions sources within the company's supply chain through a robust chain of custody model. Specifically, this is guided by SBTi's *Corporate Net-Zero Standard Version 2.0 Consultation Draft* [10] which prioritizes direct mitigation when possible. When traceability to either specific emissions sources or the activity pool currently cannot be established, or if insurmountable barriers persist in addressing a source of emissions, this methodology also acknowledges the role of indirect mitigation as an intermediate measure. The traceability of the insetting activities can be ensured with activities such as chain-of-custody documentation, blockchain-based tracking systems, farm-level purchase and application records, or third-party verified sourcing certificates. Section 1.4 Additionality, explains the requirements for these different types of projects.

- This methodology has been developed in accordance with the Proba Standard, ensuring that all guidelines, principles, and requirements outlined in the Standard are fully adhered to. Users of this methodology are expected to follow the Proba Standard to ensure consistency, credibility, and compliance with the broader framework established by Proba.

[10] https://files.sciencebasedtargets.org/production/files/Net-Zero-Standard-v2-Consultation-Draft.pdf

1.3 Eligible products

1.3.1 Types of fertilizers

- In this methodology, the eligible products are:
    - inorganic and organic fertilizers.
    - both solid and liquid fertilizers (e.g. foliar fertilizers).
    - fertilizers that partially substitute components of conventional fertilizers (e.g., the nitrogen part of an NPK fertilizer) with low-emission alternatives.

1.3.2 Regulatory compliance

- For low-emission fertilizer technologies to be eligible they must be registered in the country or region where they are being applied. Accepted evidence include:
    - Product registration certificate or license issued by the relevant national or regional agricultural authority
    - Label or technical datasheet showing the official registration number and regulatory compliance statement
    - Official database entry or listing in the national/regional fertilizer registry or approval list
    - Import permit or customs clearance documentation confirming legal entry into the country (for imported fertilizers)
    - Supplier or manufacturer declaration referencing the registration number and confirming compliance with local regulations
    - Third-party verification report confirming product registration and legal use in the specified jurisdiction
- In addition, for LMU type of projects compliance to regional guidelines is essential to ensure that the application rate is in line with local regulations. This needs to be reassessed based on the dynamic baseline directions of section 3. Baseline scenario. Accepted evidence include:
    - Copy of applicable regional guidelines or regulations specifying nutrient application limits
    - Farm nutrient management plan demonstrating adherence to regional limits
    - Fertilizer recommendation sheets or application records showing rates applied
    - Agronomist’s signed statement verifying compliance with local application standards
    - Audit or inspection reports confirming that application rates meet legal requirements

1.4 Additionality

Additionality refers to the concept that a GHG reduction project should result in emissions reductions beyond what would have occurred under a "business-as-usual" scenario or existing regulations, ensuring the reductions are truly "additional" and not simply complying with mandatory requirements.

Project developers are encouraged to use:

- the *Proba Additionality Assessment Template* [11] to assess and demonstrate additionality, as defined in section 3.6 of the Proba Standard.
- Alternatively, established tools and approaches can support project developers in assessing additionality, particularly for financial and common practice assessments. These include:
    - the UNFCCC's CDM Tool for the Demonstration and Assessment of Additionality (Version 07.0) [12] and
    - the CDM Tool for Common Practice (Version 03.1) [13].

      These tools offer structured guidance for conducting barrier analyses, determining financial attractiveness, and assessing market penetration levels of a given practice. While originally developed for offsetting contexts, they can be adapted for insetting projects when transparently applied and justified in the POD.

Depending on whether the project developer aims to use the generated claims (emission reduction certificates) in either offsetting or insetting scenarios, different requirements apply.

For the offsetting scenario the project developer must prove the following three aspects of additionality:

- Regulatory additionality: The project developer must prove that the introduction of the low-emission fertilizer technologies was not caused by local, regional or national regulations.
    - To achieve that, the project developer must prove that there is a) no regulation enforcing the use of low-emission fertilizers and b) there is a lack of financial incentive of regulatory directives to realize the proposed intervention. If subsidies are available, the project developer must show that available funding does not cover the financial gap to realize the intervention.
    - Many countries, states, regions, or economic zones have set GHG emission targets for sectors like green hydrogen or fertilizer production, supported by directives and subsidies, or incorporated the sector into a compliance system (e.g. green hydrogen

[11] https://proba.earth/hubfs/Project_Design/Proba_Additionality_Assessment_Template.pdf
[12] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-01-v7.0.0.pdf
[13] https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-24-v1.pdf

production being eligible to receive tradable EUAs in the EU, Carbon Border Adjustment Mechanism, etc.), making some project de facto not additional.
    - If a project falls under planned regulations, additionality can still be achieved if the project can prove its intervention goes beyond the set goals or realizes its impact ahead of the planned regulation timeline. In this case, the project may only be additional for a limited time until the regulation comes into effect and becomes business-as-usual.
    - If a regulation is implemented and actively enforced during the crediting period that mandates the use of low-emission fertilizer technology in scope, the crediting period for the project will end at that point, as the project would no longer meet the criteria for additionality.
- Prevalence: The project developer must prove that the introduction of low-emission fertilizer technology is not a common practice in each region included within the project area. Common practice is defined as per the guidelines of the Standard that the project developer follows. Moreover, the intervention must lead to an increase in the uptake of the fertilizer product, in the spatial boundaries of the project.
- Financial additionality: The project developer must prove that the financial incentive from carbon finance will lead to the increased adoption of the low-emission fertilizers by the farmers. Transparency on financial assistance, such as subsidies, is also required. This financial analysis may be treated as confidential by the VVB and Proba and is not required to be published in the public registry.

For the insetting scenario, the project developer must demonstrate regulatory additionality by confirming that the use of low-emission fertilizers is not mandated by the regulation. In addition, the Project Overview Description (POD) must be transparent and document information on:

- Prevalence additionality: An explanation must be provided that the use of low-emission fertilizers is not a common practice within the company's sourcing region, crop system, or market segment relevant to the intervention.
- Financial additionality: An explanation must be provided that carbon finance is positively affecting the adoption of low-emission fertilizers within the company's sourcing region, crop system, or market segment.

Note: Additionality must be reassessed when renewing the crediting period to confirm that the project remains eligible under the Proba Standard. Project developers are responsible for monitoring regulatory changes, financial conditions, and market adoption that may affect the project’s additionality. The use of a dynamic baseline is required to reflect these developments and ensure the continued credibility of the emission reductions being claimed, as seen in section 3. Baseline scenario.

1.5 Crediting Period

The crediting period is the timeframe during which a validated project can generate emission reduction certificates. After the end of the crediting period, the project needs to be re-validated to ensure that additionality is still present, the baseline scenario is reassessed including consideration of changes in regulatory and market conditions, and the project complies with the latest version of this methodology. If these requirements of the methodology are not fulfilled at the time of project re-validation then the crediting period can not be renewed. Renewals of the crediting period are permitted and may be carried out multiple times, provided that each renewal follows a full re-validation process and continues to meet the applicability criteria, methodological requirements and alignment with Proba standard.

For GHG projects adopting low-emission fertilizer technologies, the crediting period can be set up to a **maximum of 7 years**, depending on the trend in regulatory and industry landscapes toward more sustainable production practices. This duration strikes a balance between providing enough time for projects to demonstrate their environmental impact and maintaining flexibility for project adjustments and improvements (e.g., new technologies or regulations).

Note: The crediting period does not "*force*" farmers in the project to use low-emission fertilizers during the entire period, but allows them to generate emission reduction certificates if they do. For example, if a farmer uses low-emission fertilizers in only 4 out of 7 years, they would receive emission reduction certificates only for those years.

Retroactive crediting

This methodology allows for retroactive crediting, in the case the adoption of low-emission fertilizers was realized within a maximum of **two years** prior to the submission of the validation of the POD. In such cases, the crediting period will begin at the moment the intervention was first implemented, as evidenced by verifiable documentation such as purchase receipts, supplier delivery notes, application records, or other dated records that clearly establish the start date. The project developer must also fulfill the requirements set by this methodology (e.g., proof of additionality, baseline, scientific evidence, documentation) and demonstrate that the intervention was implemented with the intention of utilizing carbon finance. To avoid double counting, emission reductions that have already been claimed, credited, or reported under another carbon standard are not eligible for crediting under this methodology.

1.6 Co-benefits & no harm principle

Project developers are recommended to report on co-benefits for credibility purposes, during the POD validation and at the third year of the crediting period.

This methodology does not prescribe any calculation methods for quantifying additional benefits resulting from the adoption of low-emission fertilizers.

Proba encourages such projects to contribute to at least one or more UN Sustainable Development Goals[14], and expects that project developers, engineers or managers will consider these when preparing and designing a project.

If the Project Developer aims to claim one or more co-benefits, these should be clearly defined in the Project Overview Document (POD), along with how the impact is achieved, measured (e.g. through KPIs). In this case, relevant KPIs must be selected by the project developer and monitored throughout the years. Examples of relevant co-benefit indicators (KPIs) include:

- Percentage reduction in nitrate concentration in surface or groundwater (mg/L)
- Soil organic carbon (SOC) improvement (t/ha/year)
- Water use efficiency (kg yield/m^3 water)

For instance, the SDG Impact Assessment Tool offers a structured approach to help assess and align projects with the SDGs[15]. Some examples that could be relevant with this type of project include:

- **Zero hunger (SDG 2)**: The use of new fertilizer products could enhance crop yields while simultaneously reducing N_2O emissions. In doing so, these projects contribute to improving food production while promoting sustainable agricultural practices, aligning with SDG 2, which aims to ensure food security and sustainable food production for a growing global population.
- **Clean water and sanitation (SDG 6)**: By reducing nitrogen leaching into groundwater and surface water, the application of some low-emission fertilizer products can improve water quality, protecting freshwater ecosystems and ensuring cleaner water supplies (IPCC, 2022).
- **Climate action (SDG 13):** By reducing production or in-field emissions, low-emission fertilizers can reduce GHG emissions and directly contribute to climate change mitigation, aligning with global goals and efforts to combat climate change.
- **Life on land (SDG 15):** Reduced nitrogen runoff can lead to healthier soils and ecosystems. This also contributes to SDG 15 by supporting sustainable use of terrestrial ecosystems and avoiding land degradation and biodiversity loss.

[14] https://sdgs.un.org/goals
[15] http://sdgimpactassessmenttool.org

Project developers must adhere to the Environmental and Social do no harm principle by conducting thorough assessments to identify and evaluate potential environmental and social impacts of their GHG projects. They must also implement appropriate mitigation measures to address any identified potential risks and negative impacts, ensuring that the project does not adversely affect local ecosystems or communities, particularly vulnerable populations.

As such, in the POD, at least the following must be established:

- monitoring frequency - at least once during the crediting period
- relevant risk indicators (e.g., groundwater quality, community grievances)
- corrective pathways if harm is detected.

Proba's *Environmental and Social do no harm principle Template* [16] can be used for this purpose.

1.7 Risks

The project developer must provide a risk analysis outlining all the possible risks associated with the GHG project. Moreover, the project developer must devise and present a mitigation strategy for those risks. The risk analysis and mitigation strategy must be re-evaluated at the third year of the crediting period, as part of the verification.

Some of the risks that should be addressed are the following:

- General:
    - If the emission factors were selected directly from scientific literature, which was funded by the fertilizer industry, there might be a risk of conflict of interest. In case of potential conflict of interest, cross-check with broader relevant (scientific or validated) literature is required.
    - The crop producer might not actually apply the reported amount of product, either as an unintentional action or miscalculation or a deliberate error or falsification.
    - Events which may occur during the crop season, and may lead a) to decreased crop yields or b) additional applications of fertilizers must be thoroughly explained and documented as part of the verification cycle. Such events can negatively impact the emission reductions of the project. Examples of such events include, but are not limited to, diseases, pests, extreme weather events (e.g. heavy thunder storms and hailstorms).
- LMU-related:
    - Farmers, perceiving low-emission fertilizers as more sustainable and thus as lower-impact products, may apply them at higher rates than agronomically

[16] Available upon request

recommended. Over-application could diminish the expected emission reductions by increasing total nitrogen inputs and the resulting emissions. To mitigate this risk, project developers must monitor actual nutrient application rates and crop yields to ensure that NutUE is maintained or improved relative to the baseline. Clear guidance on proper fertilizer use should be provided to farmers to prevent unintended increases in emissions.

- The crop yield might be incorrectly measured or reported.

1.8 Leakage & permanence

1.8.1. Leakage

Leakage in the context of a GHG project is the net increase in GHG emissions that occurs outside the project boundary, directly resulting from the project's activities (IPCC, 2006). While projects are credited only for reductions within the project area, potential leakage must be assessed to ensure environmental integrity.

For interventions in scope of this methodology there may be two main risks of leakage:

1. Leakage must be accounted for when the fertilizer volumes no longer used in the project area are demonstrably sold and used by non-project actors. Given the global nature of fertilizer markets, it is not feasible to monitor all potential displacement of conventional fertilizers at a global scale. However, project developers must take reasonable steps to assess and mitigate leakage risks within the project region. The project developer must provide reasonable evidence of how these volumes were managed. Evidence can include:
    - written confirmation from fertilizer supplier or distributor that production or delivery volumes were reduced;
    - project-level fertilizer application data showing reduction in conventional fertilizer use without corresponding increase elsewhere;
    - national or regional sales/trade data showing stable or decreasing conventional fertilizer volumes;
    - market analysis or reports indicating no increase in non-project sales.

    Where this cannot be confirmed, conservative deductions apply to account for potential leakage risk. These deductions can be adjusted retrospectively if new evidence is submitted. Specifically, after a period of 4 years, the project developer may submit evidence demonstrating that the project did not result in leakage elsewhere. If such evidence is accepted by the verification and validation body, the reserved emission reductions may be credited retroactively or released from a buffer pool. If sufficient evidence is not provided at that time, the deduction remains permanent. *Table 1* presents a standardized stratification of the deductions depending on the scale of the project [17].

Table 1: Market leakage deduction for different scenarios

Project scale[18]	Scenario	Traceability of the displacement	Deduction
<1.000 ha	A	Leakage risk is considered negligible.	0%
1,000 - 10,000 ha	B	Project shows displaced fertilizer was not used outside the project (e.g. supplier confirmation, farm data, or market data)	1%
	C	Fate of displaced fertilizer unknown or unconfirmed (no evidence)	5%
>10.000 ha	D	Project shows displaced fertilizer was not used outside the project (e.g. supplier confirmation, farm data, or market data).	2%
	E	Displaced fertilizer may have been used outside the project (uncertain or evidence of redirection). No evidence, or indications of redistribution in trade/sales data.	10%

2. The second leakage risk is only applicable for interventions on the LMU level related to *b. Fertilizer in-field emissions reduction* (see section 1.2 Applicability of methodology): The use of low-emission fertilizer products that allow the in-field emissions must at least maintain the same crop yields. However, a decrease in crop yield within the project area might lead to increased production elsewhere to meet demand. If the yield decreases, it is assumed that production will need to shift to other areas, potentially resulting in more N_2O emissions due to the additional fertilizer application or land use in those areas. Crop producers are unlikely to implement and maintain a project practice that results in yield declines, since their livelihoods depend on crop harvests as a source of income.

[17] Note on Applicability for Fertilizer Distribution Projects (sourcing region type of project): For projects where the intervention is defined by the distribution or sale of a fixed quantity of low-emission fertilizer rather than activities on a defined project area, the hectare-based stratification in Table 1 must be converted to an equivalent scale in tonnes of fertilizer relevant to the sourcing or sales region. This requires identifying the main crop types in the sourcing region, determining the average nutrient application rates per crop type, and estimating the share of each crop in the region. Using this information, the total volume of fertilizer sold or displaced can be expressed as the equivalent hectares affected, which then determines the applicable leakage deduction tier from Table 1. This ensures the leakage risk classification is consistent across both area-based and volume-based project types.

[18] The project scale classification is based on commonly observed thresholds in land-based GHG methodologies, where projects below 1,000 ha are typically considered small-scale with negligible market influence, while projects above 10,000 ha are likely to affect regional fertilizer supply chains. These thresholds reflect practical differences in traceability, monitoring capacity, and risk of market leakage, and are consistent with scale categories used in AFOLU methodologies under carbon standards.

Nevertheless, to ensure leakage is not occurring and the product is working as intended, the following nutrient use efficiency (NutUE) check[19] must be done to prevent leakage:

The project developer must, both at a 3 year checkpoint following the project start and at the end of the crediting period:

- Demonstrate that the crop yield and NutUE has not declined by more than 10% in the project scenario by:
    - comparing the average within-project crop yield and NutUE (excluding years with extreme weather events) to the average **historical** baseline crop yield and NutUE (farmer log based approach) [20], **OR**
    - comparing the average within-project crop yield and NutUE to the average **regional** baseline crop yield and NutUE during the project period (market based approach) [21].
- When none of the above options can be proven, then:
    - that specific intervention becomes ineligible for future crediting, **and**
    - the project developer must adjust the project intervention to make sure that the NutUE increases, so that there is no leakage. It is expected that this adjustment will probably happen *during* the crediting period, if the crop producer identifies a crop yield decline, thus fixing the crop yield issue, and preventing the leakage to happen in the first place.

1.8.2 Permanence

The intervention targets fertilizer-related emission reductions, either from production (PCF-related) or from in-field application. In both cases, the achieved reductions are the result of avoided emissions within a given agricultural cycle, such as lower fertilizer use, reduced or delayed nitrogen losses, or improved nitrogen uptake by crops. As these are one-time emission reductions rather than stored carbon, there is no risk of reversal.

[19] The NutUE can be measured/assessed using different metrics as described in the Appendix D: Different NutUE metrics (non-exhaustive list). The project developer is required to perform the NutUE check with at least the PFP metric. Depending on their cropping system it is recommended to use further metrics, as presented in the Appendix, that make sense for their specific case.

[20] To reduce the impact of inter-annual variability, project developers may apply a weighted multi-year average NutUE, excluding years with documented extreme weather. Additionally, yield-normalized NutUE metrics (e.g., NutUE per tonne of crop biomass) may be used where appropriate, provided they are transparently justified in the POD.

[21] To demonstrate that crop yields have not declined by more than 10%, project developers can employ remote sensing (e.g., NDVI-based crop productivity assessments) or similar methods, beside self-reported farmer logs to generate realistic insights.

2. Project boundary

2.1 Scope of activities

The activities that are in scope of this methodology, which can lead to the reduction of net GHG emissions, are the following (defined based on the spatial level selected [22]):

1. LMU (Land Management Unit)
    - **a. Fertilizer Production Emissions Reduction**:
      Switching to fertilizers with a lower Product Carbon Footprint (PCF) for the nutrients applied to the LMU. This reflects a farmer's decision to use low-emission fertilizers instead of conventional ones.
      Example: A farmer replacing conventional urea with low-PCF urea produced via renewable-powered ammonia synthesis.
    - **b.i. Fertilizer In-field Emissions Reduction - EF Reduction**:
      Changing the type of fertilizer technology to lower the emission factor for direct or indirect N_2O emissions without reducing nutrient rates.
      Example: A farmer replacing conventional calcium nitrate fertilizer with an ammonium sulfate fertilizer, which has a lower direct N_2O emission factor due to its sulfate component influencing soil chemistry, while keeping the nitrogen application rate unchanged [23] .
    - **b.ii. Fertilizer In-field Emissions Reduction - Nutrient Rate Reduction:**
      Interventions that lower the amount of nutrient applied, while maintaining yield levels [24], thereby reducing absolute emissions.
      Example: Using precision application tools to cut nitrogen rates by 15% without yield loss.
2. Sourcing Region Level
    - **a. Fertilizer Production Emissions Reduction:**
      Distributing low-PCF fertilizers so that farmers in the sourcing region adopt them.
      Example: A cooperative supplying the entire region with low-emission NPK blends instead of conventional ones.
    - **b.i. Fertilizer In-field Emissions Reduction - EF Reduction:**
      Regional-scale adoption of fertilizers or practices that lower emission factors.
      Example: Inducing a switch from urea to CAN across the sourcing region.

[22] *Land Management Unit* and *Sourcing Region* are spatial levels, which are explained in section 2.3 Spatial boundary
[23] As an example, a one-year field study in temperate grassland (Rahman & Forrestal, 2021) found that ammonium sulfate fertilizer had a direct N_2O emission factor of 0.35%, compared to 1.02% for calcium nitrate, representing a 66% reduction in EF with no difference in yield or nitrogen uptake. This example is for illustrative purposes only; the project developer is responsible for selecting an appropriate baseline and project fertilizer type, and corresponding emission factors, that reflect their specific circumstances.
[24] This must be proven through the NutUE check, as described in section 1.8 Leakage & permanence.

Optional for LMU type of projects: This methodology allows for the inclusion of other management practices in addition to the adoption of low-emission fertilizers, provided there is scientific evidence demonstrating that these practices do not lead to an increase in GHG emissions. As mentioned in section 1.2 Applicability, this methodology can work synergistically with other GHG methodologies or programs that target emissions reductions or removals in areas outside the scope of this methodology. For instance, it can be combined with approaches involving the introduction of controlled-release fertilizers (CRFs) or stabilized fertilizers with nitrification / urease inhibitors.

Note on special cases of a. Fertilizer Production Emissions Reduction:

1. **Partial nutrient substitution within multi-nutrient fertilizers (e.g., NPK) is allowed**. For example, if only one nutrient component of an NPK fertilizer is replaced with a low-emission alternative (e.g., replacing conventional urea in an NPK 15-15-15 with low-emission urea):
    - The project emissions calculation must isolate the N component of the product.
    - The carbon footprint of the other components remains unchanged and is treated as neutral or excluded.
    - Emission reductions are only claimed for the difference in EF for the low-emission nutrient fraction.
    - The project developer must clearly document the composition of the NPK fertilizer, the substitution pathway, and any assumptions made about the emissions associated with the P and K components.
2. **Interventions targeting upstream inputs (e.g., low-emission ammonia) are allowed**. If the intervention involves switching to low-emission ammonia as a precursor input, and not directly the final fertilizer type [25]:
    - The project EF must reflect the reduction in cradle-to-gate emissions due to the use of low-emission ammonia in the production process.
    - In this case, the EF of the final fertilizer product (e.g., urea, AN, UAN) is adjusted downwards based on LCA or process data comparing conventional and low-emission ammonia inputs. Projects must demonstrate traceability and control over the supply chain, through strict accounting based on a mass balance approach, to credibly attribute emissions reductions to upstream interventions like low-emission ammonia .

[25] Example: A fertilizer distributor sources part of its ammonium sulfate nitrate (ASN) feedstock from a “green ammonia” facility where ammonia is produced using renewable-powered electrolysis instead of conventional natural gas-based Haber–Bosch. The Product Carbon Footprint (PCF) of the ammonia feedstock decreases from ~2.8 t CO_2e/t NH_3 to ~0.4 t CO_2e/t NH_3. Using a mass balance chain-of-custody model, the proportion of low-carbon ammonia in total ASN production is calculated on a nitrogen-molecule basis, and the corresponding reduction is allocated to the NPK blends distributed as “low-carbon” variants. This ensures the EF adjustment reflects the verified upstream ammonia footprint reduction, with third-party validation to avoid double counting

2.2 GHG sources

In this methodology, the impact of the low-emission fertilizers starting from their production up until their application on the field is in scope. Specifically the activities (as seen in *Figure 1*) that result in GHG emissions and are in scope include:

1. Fertilizer production emissions (cradle-to-gate emissions of fertilizers). These include any type of fertilizer related to the baseline and project (inorganic or organic).
2. Transportation of the fertilizers from the production location to the project location. Certain PCFs include these emissions already. If this is the case, then these must be updated to reflect the actual transportation emissions of the baseline and project and avoid potential double counting.
3. Field spreading of the fertilizers using machinery [26]. This is not expected to be impacted in most cases where the low-emission fertilizer is physically similar to the baseline fertilizer. However, if the product has a significantly different weight or volume than the baseline fertilizer, which might lead to more or less tractor passes or consumption of fuel, then this needs to be accounted for. The project developer must be transparent in his choice to include or not the emissions from this activity. In addition, an intervention might include the switch to low-emission fuel for the fertilizer spreading. This can be included in this activity. This activity can only be accounted for as a GHG benefit for LMU type of projects.
4. Application of fertilizers: Emission reductions from the application of nitrogen-containing fertilizers[27] [28], specifically direct and indirect nitrous oxide (N_2O) emissions, are eligible under two scenarios *b.i. EF related* (LMU and regional) and *b.ii. Nut-rate related* (only for LMU type of projects). If changes in organic fertilization (for example increased application of manure) happen as part of the intervention, which can affect the in-field emissions, then this needs to be accounted for as well.

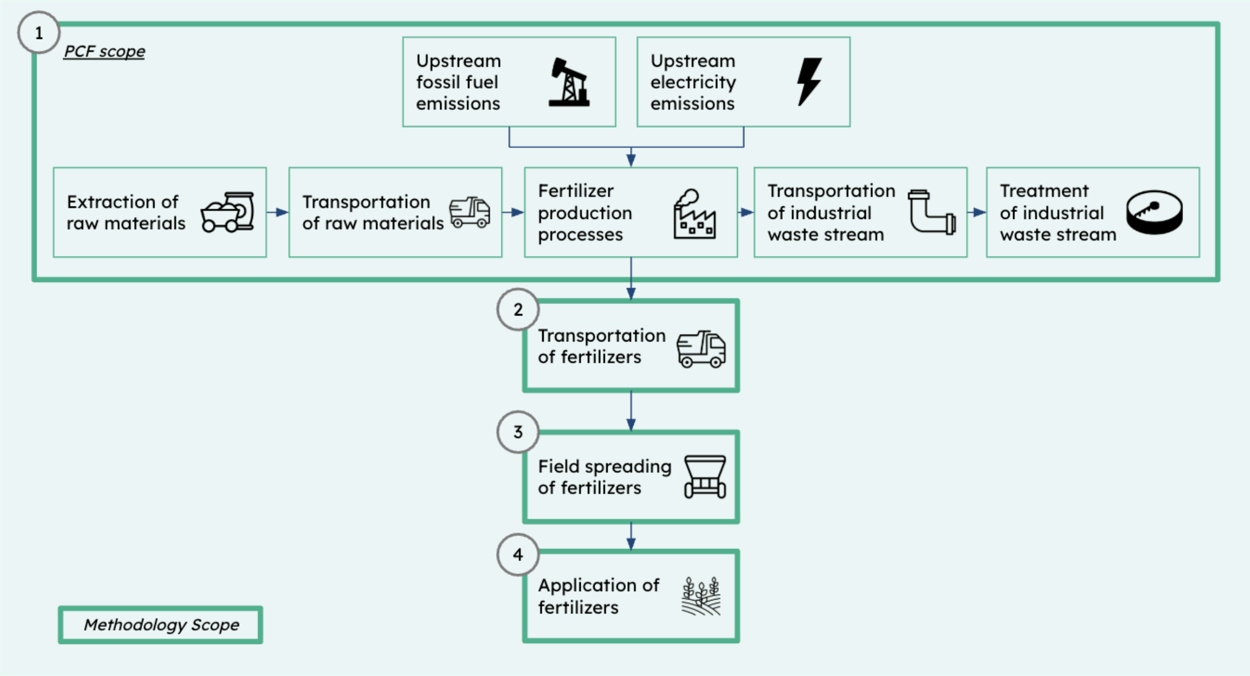
[26] It is acknowledged that there are various other activities related to farming that might lead to GHG emissions. However, for the purposes of this methodology we consider that field spreading of fertilizers is the one with the highest material impact. As mentioned in section 1.2 Applicability, "*The project developer must be transparent and report on additional activities that happen along with or because of the introduction of low-emission fertilizers, which can lead to material changes of emissions on the field*"

[27] Sourcing region types of projects are excluded from claiming a GHG benefit from reduced application emissions, as there is no way to trace the actual application rate on the fields.

[28] During the usage of nitrogen fertilizers, both direct and indirect GHG emissions are generated (Menegat et al., 2022). Direct N_2O emissions are those emitted directly from the fields where fertilizers are applied. Indirect N_2O emissions occur when nitrogen lost to the atmosphere as NH_3 (from ammonia volatilization) or leached as nitrate into water systems is later converted to N_2O outside the original application site (Lam et al., 2018). In contrast, phosphorus-based (P) and potassium-based (K) fertilizers typically do not emit substantial quantities of GHGs emissions. However, if the project produces a P or K-based fertilizer that emits significant GHGs compared to the baseline, those emissions must be accounted for, and the method for calculating and verifying these emissions must be provided.

The activities in scope are presented in *Figure 1* below:

Figure 1: Activities in scope for the GHG sources calculations



Greenhouse gases emitted for each activity that is covered under this methodology are presented in *Table 2* below. It should be noted that all the emissions should be expressed as carbon dioxide equivalents (CO_2e).

Table 2: Emission sources covered under this methodology

	Activity/Source	*GHG*	*Included*	*Justification*
Baseline	(1) Fertilizer production emissions	CO_2e	Yes	Significant source that must be accounted for
	(2) Transportation of inorganic fertilizers	CO_2	Yes	Main emission from combustion of fuel
		CH_4	No	Typically not material
		N_2O	No	Typically not material
	(3) Field spreading of inorganic fertilizers	CO_2	Yes	Main emission from combustion of fuel
		CH_4	No	Typically not material
		N_2O	No	Typically not material
	(4) Application of inorganic fertilizers	CO_2	No	Out of scope
		CH_4	No	Out of scope

	Activity/Source	*GHG*	*Included*	*Justification*
		N_2O	Yes	N_2O is the major emitted GHG from the use of nitrogen fertilizers
Project	(1) Fertilizer production emissions	CO_2e	Yes	Significant source that must be accounted for
	(2) Transportation of low-emission inorganic fertilizers	CO_2	Yes	Main emission from combustion of fuel
		CH_4	No	Typically not material
		N_2O	No	Typically not material
	(3) Field spreading of low-emission inorganic fertilizers	CO_2	Yes	Main emission from combustion of fuel
		CH_4	No	Typically not material
		N_2O	No	Typically not material
	(4) Application of low-emission inorganic fertilizers	CO_2	No	Out of scope
		CH_4	No	Out of scope
		N_2O	Yes	N_2O is the major emitted GHG from the use of nitrogen fertilizers

2.3 Spatial boundaries

- The spatial boundaries of a project are defined by the geographic area where the activities impacting GHG emissions take place. Local and regional regulations, as well as environmental sensitivity [29], must also be considered when defining these boundaries.
- Project developers must justify their selection of spatial boundaries based on factors such as the access to farmer level data, homogeneity and level of insights.
- If a project includes multiple scenarios, such as different crops or fertilizer types, the project developer must explicitly define the scope of these scenarios within the Project Overview Document (POD). This ensures clarity on what combinations of fertilizers, crops, and management practices are included in the project scope. During verification, where the actual implementation of the project is assessed, the reported scenarios must be grouped based on similar management practices. The emission impact must then be calculated separately for each group to maintain methodological consistency and accuracy in reporting.
- This methodology allows two possible levels of spatial boundaries as presented in Table 3.

Table 3: Differences between the two levels of spatial boundaries allowed under this methodology

	Land Management Unit (LMU) level	*Sourcing Region level*
Definition	A clearly defined area of land under consistent management, where fertilizer application can be directly monitored and attributed. This is similar to *LMU* as per the GHG Protocol [30].	A geographically distinct area characterized by common environmental, climatic, and land use conditions. This is similar to the *Sourcing region* as per the GHG Protocol.
Data availability	• Individual LMU level data • Average regional data from multiple fields, farmers, or cooperatives within a defined region	• Average regional data from multiple fields, farmers, or cooperatives within a defined region
EF selection options	• **Context specific Tier 2-3 EF data** • Aggregated Tier 1-2 EF data (higher uncertainty)	• Aggregated Tier 1-2 EF data (higher uncertainty)
Baseline is defined based on [31]:	• Historical LMU data • Regional data • Counterfactually	• Regional data • Counterfactually

[29] Environmental sensitivity refers to the vulnerability of ecosystems or regions to environmental impacts, such as water or air pollution, soil degradation, or biodiversity loss.
[30] https://ghgprotocol.org/land-sector-and-removals-guidance
[31] Explanation on section 3. Baseline scenario

		Land Management Unit (LMU) level	*Sourcing Region level*
NutUE check[32]		• Comparison of LMU historic NutUE with regional NutUE	• Transparency on regional NutUE
Types of interventions allowed	*a. Fertilizer production emissions reduction*	Allowed	Allowed
	b.i. Fertilizer in-field emissions reduction: EF related	Allowed	Allowed
	b.ii. Fertilizer in-field emissions reduction: Nut-rate related	Allowed	**Not allowed** (since field level monitoring is not possible)
Emission reduction quantification of additional practices on top of the usage of low-emission fertilizer technologies		Allowed	**Not allowed**
Default deduction to the total net GHG emission reductions[33]		0%	**5%**

Practical guidance for project developers on selecting between spatial level approaches:

- **Use LMU Level if:**
  - You have access to field-level data, including crop type, fertilizer use, and yields for each participating farm or field.
  - You aim for higher accuracy and lower uncertainty in emission estimates, potentially enabling greater GHG reduction claims.
  - You want to monitor site-specific changes, such as reductions in nitrogen application rate or improved efficiency at the farm level.
- **Use Sourcing Region Level if**:
  - LMU field-level data is not available, and you need to rely on aggregated regional information (e.g., from cooperatives, national/regional data, or supplier records).
  - Your project operates at a large scale involving many farmers with similar practices, but without granular farm-level visibility.
  - You are willing to accept higher uncertainty and more conservative emission reductions in exchange for streamlined data collection.

[32] To ensure that the baseline fertilization is not excessive and avoids rewarding projects that apply nutrients beyond typical regional norms, which could otherwise inflate emission reductions linked to the improved NutUE
[33] In alignment with the SBTi and GHG Protocol's guidance encouraging greater transparency and traceability through field-level interventions, this methodology applies a 5% deduction to the net GHG emission reductions when the sourcing region spatial boundary is used. This deduction is intended to further incentivize the adoption of LMU type of projects.

2.4 Temporal boundary

The temporal boundaries define the start and end of the monitoring and reporting process.

For Land Management Unit level projects:

- The boundaries follow the entire cultivation cycle of the target crop and can vary based on the timing of fertilizer application.
- The start of the temporal boundaries is defined as the date of the first application of the fertilizer.
- The end of the temporal boundaries is defined as the final harvest date of the target crop within the participating field.
- The project developer must select and justify the temporal boundaries based on the crop's fertilizer application schedule, which can vary by region. A crop calendar must be consulted to determine the specific timeline for each region. An example resource for this is the USDA Foreign Agricultural Service[34], which provides crop calendar charts for various regions and major crops. However, it is critical to supplement these sources with local, region-specific data when determining the exact temporal boundaries and ensuring that EFs appropriately account for nitrogen dynamics across the entire crop cycle.

For sourcing region level projects:

- The temporal boundary must cover at least **one year**.
    - This temporal boundary is used because, at the sourcing region scale, sales of low-emission fertilizer technologies may span multiple cropping systems and planting seasons. Within one calendar year, it is possible to capture several crop cycles for short-duration or row crops (e.g., maize, wheat, etc.), reflecting an accurate representation of nitrogen use and related emissions across a variety of cropping systems and management practices.
    - The recommended period is one year, but can be longer depending on the specificities of the project as explained above.

[34] https://ipad.fas.usda.gov/ogamaps/cropcalendar.aspx

3. Baseline scenario

The baseline scenario represents the emissions that would occur based on the business as usual agricultural management practices. This includes fertilizer management and other relevant activities, **without the introduction of low-emission fertilizer technologies**.

Depending on the spatial level selected and intervention type, the project developer must establish a) the baseline nutrient application rate (Nut-rate) and b) the baseline fertilizer type. Guidance on how to select the corresponding approach is presented in Table 4. There are three approaches for defining the baseline: a) historical, b) counterfactual or c) regional. These different approaches are presented in Table 5. Finally, if the project is done on a LMU level and includes in-field emissions reduction, then they must conduct a NutUE Performance Test as presented later in this section.

Table 4: Baseline parameter determination and nutrient use efficiency testing by spatial level and intervention type. [35]

Spatial level	*Intervention type*	*Baseline Nutrient-rate*	*Baseline Fertilizer Type*	*NutUE Performance test*
LMU	*a. Fertilizer production emissions reduction*	1. Historical 2. Counterfactual	1. Historical [36] 2. Counterfactual [37]	• Not mandatory, but recommended
	b.i. Fertilizer in-field emissions reduction: EF reduction [38]	1. Historical 2. Counterfactual	1. Historical 2. Counterfactual	• Mandatory
	b.ii. Fertilizer in-field emissions reduction: Nut-rate reduction	1. Historical	1. Historical	• Mandatory
Sourcing region	*a. Fertilizer production emissions reduction*	1. Regional [39]	1. Regional [40] 2. Counterfactual [41]	• Not applicable • Must be transparent on region's average NutUE
	b.i. Fertilizer in-field emissions reduction: EF reduction	1. Regional [42]	1. Regional	• Not applicable • Must be transparent on region's average NutUE

[35] The options for defining baseline parameters are presented with a fallback hierarchy, where option 1 is the priority approach and option 2 is the secondary option if priority data are not available.
[36] Example: In the past the LMU used CAN 50% of the time and Urea the other 50%. The baseline would be the mix of the two.
[37] Example: Project fertilizer = CAN produced with low-emission ammonia, Baseline: CAN that can be sourced in the region.
[38] Note for b.i. & b.ii. : To avoid the rewarding of cropping systems that are overapplying nutrients, both the baseline and the project Nut-rate must not be higher than the average regional Nut-rate (including any recent regulatory changes), unless there is a strong agronomic justification for it.
[39] This is relevant for projects aiming to generate emission reduction units for their own fertilizer supply shed. In this case, they need to define the crop mix and corresponding proportions as well as the average regional Nut-rates. These can then be claimed by companies for which their crop demand shed matches the fertilizer supply shed, and thus can make inventory-based claims. In contrast, project-based emission reduction claims do not require this crop level analysis.
[40] Required for inventory-based emission reduction claims (see previous footnote).
[41] If the aim is to generate project-based claims, then a counterfactual baseline can be used.
[42] In this case, the crop mix analysis is required for any type of projects, since the EF reduction must be tied to the crop type

Description of NutUE Performance test

1. This includes comparing the LMU's historic NutUE with regional benchmark NutUE values[43]
2. The purpose is to verify that the project's baseline practices are following the region's guidelines and are not overapplying nutrients, which might in thus inflate the potential in-field emission reductions.
3. The following data and equation must be provided and used for the calculation:
    - Total fertilizer applied per hectare (kg Nut/ha)
    - Total crop yield per hectare (t/ha)
    - Equation:

$$NutUE = \frac{Crop\ Yield\ (t/ha)}{Total\ Fertilizer\ Nut\ applied\ (kg\ Nut/ha)} \quad (1)$$

4. NutUE can vary from year to year due to weather patterns, pest diseases, or changes in soil conditions. Project developers are required to use multi-year historical data, such as a moving average (see Appendix C: Different metrics of GHG emissions) of the last 4 growing seasons, to better represent typical practices. Single-year data may only be used in exceptional cases (e.g., newly established farms) and must be clearly justified.
5. If a field or region follows a crop rotation system (e.g., legumes in one year, cereals in the next), the baseline NutUE must be specific to the focus crop in the rotation
6. The NutUE test must be conducted during the first validation of the project and then at least every 3 years during the project verification.

[43] If regional benchmark NutUE values are not available, agronomic recommendations from a recognized scientific institution or body should be used as a reference

Table 5: Explanation of the different baselining approaches and their accepted data

Approach	*Baseline Nut-rate*	*Baseline Fertilizer type*	Accepted data sources [44]
Historical	• Defined based on the average nutrient application rate historically used at the LMU level for similar agricultural practices.	• Defined based on the historical range of fertilizer products and their corresponding proportions used at the LMU level for similar agricultural practices.	1. Official farm records or verified input purchase records for the relevant LMU, covering multiple past seasons of similar agricultural practices. Insights from agronomic experts can also be taken into account to make sure the baseline is defined accurately for the specific cropping system. 2. Documented agronomic data or extension service records specific to the LMU or its immediate surroundings for similar crop and management conditions. 3. Farmer surveys or structured interviews, supported by corroborating evidence such as receipts, cooperative sales data, or supplier records. Note: Data from the last 3 growing seasons (crop relevant) must be used.
Regional	• Defined based on the average nutrient application rate used in the region for similar agricultural practices, considering factors such as crop type, management practices, and input availability. • Throughout the crediting period, the baseline nutrient rate must be updated every 3 years. This may affect the nutrient rate reduction potential (only relevant for the scenario "*b.ii. Fertilizer in-field emissions: Nut-rate reduction*") [45].	• Defined based on the range of fertilizer products and their corresponding proportions that could realistically be used in the project's farming system within the sourcing region.	1. Official national statistics: Government-published agricultural, trade, and production datasets (e.g., USDA, Eurostat, national statistical offices). 2. International organization databases: FAOSTAT, World Bank, OECD, UN Comtrade. 3. Recognized industry association reports: International Fertilizer Association (IFA), The Fertilizer Institute, and other (regional) bodies. 4. Peer-reviewed literature: Studies providing robust, transparent, and recent regional market data. 5. Certified third-party market research: Subscription-based or commercial datasets from reputable providers (e.g., CRU, Argus, ICIS). If historic farmer log data are available, then these can be used to support the market analysis. 6. Other credible public sources: NGO reports, open-access market surveys, or expert-verified datasets, with clear documentation of methodology and limitations. Note: The most recent regional data must be prioritized.
Counter-factual	• Defined based on the project's fertilizer Nut-rate.	• Defined based on the project's fertilizer type.	1. Project-level data proving the fertilizer type or Nut-rate (see section 6. Monitoring, Reporting and Verification)

[44] The accepted sources options are presented with a fallback hierarchy (descending priority).
[45] Given that in many regions and markets regulatory changes and the industry standards are evolving rapidly and this can have a severe impact on baseline calculations, a dynamic baseline is required. If the regional baseline has changed, then the project's baseline must be re-established based on the regional baseline. Moreover, updates which affect additionality (regulatory changes, subsidies, tax incentives, etc.) must be transparently presented in the verification report.

4 Calculation of GHG emissions

The project developer must calculate the **total GHG emissions** for both the baseline and project scenario. To achieve that, they need to use the equations presented in this section. Baseline and project emissions for each activity step must be transformed into tonnes of CO_2e for each verification period.

The total (baseline or project) emissions can be calculated as the sum of the subsequent activities (a), as seen in Table 6.

If only *one intervention* [46] takes place in the project, then:

$$E = \sum_{a=i}^{n} E_a \tag{1a}$$

If multiple interventions (x) take place in the project, then:

$$E = \sum_{x} \sum_{a=i}^{v} E_{a,x} \tag{1b}$$

Where:

E	=	Total (baseline or project) GHG emissions (tCO_2e)
$E_{a,x}$	=	Emissions of activity a for the intervention x (tCO_2e).
x	=	Total amount of interventions

The three approaches for quantifying baseline and project emission are listed in Table 6. In cases where more than one EF-data reference approach is allowed for a given activity, then the same approach must be used to calculate both the project and baseline scenarios. Regarding the prioritization of the EF sources, the project developers must prioritize granular data compared to aggregated data whenever possible (Tier 3 > Tier 2 > Tier 1). See appendix A.1.1. Prioritization of EF sources and Tiers.

[46] "One intervention" refers to a group of project activities that share similar characteristics, such as the same type of low-emission fertilizer, crop, and management conditions, applied across a set of farms. It is the responsibility of the project developer to define and group interventions in a logical and consistent way to ensure that subsets of the project are comparable, thereby simplifying MRV and emissions quantification.

Table 6: Summary of equations used to calculate the total emissions and approaches to retrieve the EF

Activity & equation	Approach 1: Emission factors from scientific literature	Approach 2: Direct measurement	Approach 3: LCA /PCF data
(1) Fertilizer cradle-to-gate emissions [47] $E_{1a} = EF_{IN} \cdot FIN \cdot A$	X		X
(2) Transportation of fertilizers $E_2 = \sum_{c} \sum_{x} (EF_m \cdot Q_{x,c,m} \cdot D_{x,c,m})$	X		
(3) Field spreading of fertilizer products $E_3 = \sum_{cf} \sum_{mf} (EF_{mf} \cdot D_{cf,mf} \cdot N_f)$	X		
(4a) Direct N_2O emissions $E_{4a} = [(FIN \cdot EF_{in,direct\_N2O}) + (FON \cdot EF_{org,direct\_N2O})] \cdot 44/28 \cdot A \cdot GWP_{N_2O}$	X	X	
(4b) Indirect ammonia volatilization $E_{4b} = [(FIN \cdot NH_3\, volatilized_{in}) + (FON \cdot NH_3\, volatilized_{org})] \cdot EF_{.indirect\_v} \cdot 44/28 \cdot A \cdot GWP_{N_2O}$	X	X	
(4c) Indirect leaching and runoff of N $E_{4c} = [(F_{in} \cdot EF_{in,\,indirect\_l} \cdot N\, leaching_{in}) + (F_{org} \cdot EF_{org,\,indirect\_l} \cdot N\, leaching_{org})] \cdot 44/28 \cdot A \cdot GWP_{N_2O}$	X	X	

[47] This equation gets more granular depending on different scenarios. See sub-section below.

4.1 EF-data reference approaches

Approach 1: Emission factors retrieved from scientific studies

For the quantification of GHG emissions (direct and indirect N_2O emissions), EFs originating from available scientific literature can be used. Documented emissions of N_2O should be supported by emission factors that are among others characterized by lower uncertainties than Tier 1 EF. Definitions of Tier 1, 2, and 3 EF are described in detail in the appendix A.1 Tier definitions.

Tier 2 emission factors must meet specific criteria to be considered valid and applicable for use by project developers in this GHG methodology. These criteria ensure that the EFs or emission reduction percentages reflect characteristics of the project and are derived from scientific studies of high experimental quality standards.

Project developers can extract EF from scientific studies that are relevant to their environmental factors and management practices and aggregate them to create relevant Tier 2 - type of EF. Higher-tier emission factors (Tier 3 > Tier 2 > Tier 1) must be prioritized. If lower-tier EF are used, the project developer must justify why higher-tier options were not feasible (see appendix A.1.1. Prioritization of EF sources and Tiers)

The guidelines for selecting suitable EFs are organized into three main sections, which the project developer must follow:

1. **Alignment with the influential environmental factors and management practices (with high relative importance) of the study:** Emission factors must be selected based on their relevance to both the project's key environmental factors and management practices from the referenced studies to ensure consistency and applicability. Where exact alignment between the study conditions and the project characteristics is not available, project developers may use emission factors derived from studies that partially align with key parameters (e.g., soil type, climate type, fertilizer, etc.). In such cases, developers must select a conservative EF value from the available data (use of standard deviation ranges). The procedure of selecting an appropriate value is described in section 4.3 Uncertainty and must be properly justified and documented.
2. **Utilization of meta-analyses papers:** Meta-analyses can be valuable when emission factors from individual studies are limited or when a broader evidence base is needed to support a representative value. Meta-analyses must report or assess heterogeneity (I^2) among studies. If I^2 is not provided, developers must provide evidence of variability (e.g., range, SD, forest plot) and justify reliability. If high heterogeneity is evident (e.g., $I^2 > 75\%$ or clear visual spread), an uncertainty buffer of 10% must be applied unless justified via subgroup analysis.

Project developers may use data from meta-analyses as sources of emission factors or emission reduction percentages, provided that a clear and well-documented selection process is followed. In meta analyses, emission reduction results are typically presented across several subgroup factors (such as soil type, crop type, etc.), each with its own range of values. When multiple relevant subgroups apply, project developers can identify where these ranges overlap and select a conservative value from within that intersection (see 4.3 Uncertainty). If multiple eligible and relevant meta-analyses exist and the project developer wants to use them, then an average EF (reduction) must be calculated across all qualified sources. If applicable, the average must be accompanied by a weighted uncertainty estimate to ensure transparency and reflect variability across sources.

3. **Experimental design (of studies/trials):** The experimental trails/scientific studies and meta analyses used to extract EFs or emission reduction percentages must follow high experimental design quality criteria/standards.

Note: Details and specific instructions for each of these sections are explained in the appendix A.2 Emission factor selection criteria based on scientific studies.

When a range of possible emission factors is provided (f.i. based on a meta-analysis), the methodology requires that the selected EF must have a confidence level of at least 95%. This means that the EF value chosen should fall within the range where there is greater than 95% certainty that it accurately represents the true emission factor under the specified conditions.

This procedure must be thoroughly presented/documented in order for third-party "Verification and validation bodies (VVBs)" to investigate and assess the suitability of the selected EFs during the implementation and reporting stages of the project.

Approach 2: Direct measurements

This approach is focusing on the utilization of project-specific emissions/emission factors that are derived from direct measurement on the field (e.g., using chambers), which provide actual data that reflect field conditions. The measurement methods should be conducted by qualified scientific teams and the process must follow the guidelines presented in the appendix A.2.3 Quality criteria of experimental design (of studies/trials).

A detailed explanation of the methods used to calculate and account for uncertainties must be included (uncertainty analysis).

Approach 3: PCF or LCA data

This section sets out the evidence requirements for determining the Product Carbon Footprint (PCF) emission factors (EF) of fertilizers used in both the baseline and project scenarios. It defines acceptable evidence sources, methodological requirements, and reporting obligations to ensure that PCF values are reliable, comparable, and transparently documented. The requirements are presented in the table below.

Table 7: Evidence requirements for fertilizer PCF emission factors

Evidence type	Requirements
Source	• The evidence for the PCF of the fertilizers (baseline or project) must be sourced from one of the following sources in descending priority, depending on availability of data [48]: ○ fertilizer producers through verified Environmental Product Declarations (EPDs), PCFs or sustainability reports, ○ widely accepted industry tools and platforms, such as CoolFarmTool, ecoinvent, Agri-footprint database, Carbon Footprint Calculator for Fertilizer Products[49] ○ Tier 1-2 industry reports such as the one published by the International Fertilizer Society titled "*The carbon footprint of fertilizer production: regional reference values*" [50] or, ○ Relevant scientific literature ○ Non-validated individual PCF data directly provided by fertilizer suppliers. If only non-validated individual PCF values are available, their use is allowable under the following conditions: ■ a) The PCF must be cross-verified against at least one value from higher-tier sources (preferably for a comparable fertilizer type and manufacturing context). Significant deviations must be explained and justified. ■ b) The underlying methodology must be aligned with ISO 14067, ISO 14040/44 or the GHG Protocol Product Standard ■ c) The lack of third-party verification must be clearly disclosed
Method	• The project developer must clearly present the calculation method used for determining the product carbon footprint (PCF) of fertilizers. Accepted methods include: ○ a) ISO 14067 (Carbon footprint of products), ○ b) ISO 14040/14044 (Life cycle assessment principles and requirements), ○ c) the GHG Protocol Product Standard.
Validation body	• The body that conducted the calculation of the PCF must be disclosed.
Validation year	• The year that the validation of the PCF was done must be disclosed. • This should be preferably less than 10 years old. • Project developers must report any changes in fertilizer formulations or suppliers that affect emission factors through the monitoring framework

[48] The selection must be justified in the POD by the project developer
[49] https://app.calcfert.com/login/?redirect_to=https%3A%2F%2Fapp.calcfert.com%2F
[50] https://www.fertilizerseurope.com/wp-content/uploads/2020/01/The-carbon-footprint-of-fertilizer-production_Regional-reference-values.pdf

	(section 6. Monitoring, Reporting and Verification) and must be transparently reported and justified in the verification report.
Baseline and project alignment	• The same data source and methodological standard must be prioritized for both baseline and project emission factor (EF) PCFs to ensure comparability. • If different sources or methods are used, these must be explicitly disclosed, with a clear explanation of methodological differences and their potential impact on the results. Specifically in this case, project developers must: ○ Explain methodological differences: Describe any differences in system boundaries, functional units, and allocation rules between the standards. ○ Identify EF differences: Specify where and how the emission factor values differ as a result of these methodological variations. ○ Apply a conservative approach: Where uncertainties or discrepancies exist between standards, use a conservative estimation method to ensure the integrity of the results.
Uncertainty reporting	• The reported measure of uncertainty must be disclosed (e.g. standard deviation, confidence interval, or similar)
Relevance to the project	• The relevance of the selected PCF must be justified. • This must be cross checked with the actual fertilizer product used in the project (based on the documentation supplied in the MRV).

4.2 Equation of each activity step

The following equations shall be applied to quantify GHG emissions for both the baseline and project intervention. The differentiation between baseline and project conditions is reflected in the selection of the appropriate emission factors (EFs) used in the calculation. Emissions must be transformed into tonnes of CO_2e for each verification period.

(1a) Baseline fertilizer cradle-to-gate emissions

Depending on the type of baseline approach used, the baseline emissions are calculated as follows.

For **counterfactual** (CF) approach, baseline emissions are calculated based on the amount of intervention's fertilizer volume:

$$E_{PCF,\, baseline,\, CF} = A \times N\% \times EF \qquad (2a)$$

Where:

$E_{PCF,\, baseline,\, CF}$	=	the total cradle-to-gate GHG emissions associated with the counterfactual baseline fertilizer product, kg CO_2e

A = amount of low-emission fertilizer, in kg product [51]

$N\%$ = nutrient content of baseline fertilizer, in % by weight

EF = emission factor associated with the baseline fertilizer, in kg CO_2e per kg Nut applied

For the **historical** and **regional** approaches, the baseline is based on an analysis to determine a realistic mix of conventional fertilizer types that could be used in the project's context. The output of the analysis must be a **weighted mix** of fertilizer types, each associated with a proportion representing its share in the relevant scenario. In these cases, baseline emissions are calculated by summing the emissions from each fertilizer type in the baseline mix, weighted by their proportion and using appropriate emission factors (EFs):

$$E_{PCF,\,baseline,\,HR} = \sum_{i=1}^{n} (A_i \times N\%_i \times EF_i) \quad (2b)$$

Where:

$E_{PCF,\,baseline,\,HR}$ = The total cradle-to-gate GHG emissions associated with the historical or regional baseline fertilizer products applied

i = index of each fertilizer type in the baseline mix

A_i = application rate of fertilizer i, derived from the total Nut-rate and share of fertilizer i, in kg product/ha

$N\%_i$ = nutrient content of fertilizer i, in % by weight

EF_i = emission factor associated with fertilizer type i , in kg CO_2e per kg N applied

The total baseline Nut-rate (kg N/ha) is apportioned across the baseline fertilizer mix in proportion to each product's share. This ensures that the sum of N from all fertilizers equals the total baseline Nut-rate, even if N% varies across fertilizers. As such,

$$A_i = \left(\frac{Nrate \times S_i}{N\%_i}\right) \quad (3)$$

Where:

$Nrate$ = total baseline Nut-rate, in kg N/ha

S_i = share of fertilizer i in the baseline mix (e.g., 50%)

[51] The unit can be adjusted kg / ha if needed. See Appendix C: Different metrics of GHG emissions

(1b) Project product cradle-to-gate emissions

Project emissions represent the GHG emissions resulting from the actual implementation of the intervention using a low-emission product. The project fertilizer is the actual product applied under the intervention scenario. Its total Nut content and product composition must be clearly documented and verifiable.

If only one low-emission fertilizer product is used, the project emissions are calculated as:

$$E_{PCF,\,project} = A \times N\% \times EF \tag{4}$$

Where:

$E_{PCF,\,project}$	=	The total cradle-to-gate GHG emissions associated with the low-emission fertilizer products applied under the project scenario
A	=	application rate of low-emission fertilizer, in kg product/ha
$N\%$	=	nutrient content of low-emission fertilizer, in % by weight
EF	=	emission factor associated with the low-emission fertilizer, in kg CO_2e per kg N applied

If more than one low-emission fertilizer product is used, project emissions must be calculated using a weighted Sum (Σ) approach, based on each product's share in the overall Nut applied:

$$E_{PCF,\,project} = \sum_{j=1}^{n} (A_j \times N\%_j \times EF_j) \tag{5}$$

Where:

j	=	index of each low-emission fertilizer type in the project
A_j	=	application rate of low-emission fertilizer j, in kg product/ha
$N\%_j$	=	nutrient content of fertilizer j, in % by weight
EF_j	=	emission factor associated with low-emission fertilizer type j, in kg CO_2e per kg N applied

(2) Transportation of fertilizers

The emissions are calculated for each fertilizer product (x), based on the distance between the fertilizer factory and the fertilizer usage location (c), and the mode of transportation used (m).

$$E_2 = \sum_c \sum_x (EF_m \cdot Q_{x,c,m} \cdot D_{x,c,m}) \quad (6)$$

Where:

E_2	=	Emissions of the transportation of fertilizers (tCO_2e/year)
EF_m	=	Emission factor of the mode of transportation m (tCO_2e/tonne-km) [52]
$Q_{x,c,m}$	=	Quantity of fertilizer product x sent to fertilizer usage location c via the mode of transportation m (t/year)
$D_{x,c,m}$	=	Distance traveled of fertilizer product x to the fertilizer usage location c via the mode of transportation m (km). If the specific fertilizer usage location is not known (for example for sourcing region type of projects), a conservative average distance can be assumed, provided that it is thoroughly justified in the POD.

(3) Field spreading of fertilizer products

These emissions include activities from the machinery used during the application process. The emissions are calculated based on the vehicle type or the field spreading machinery (mf) which apply the fertilizer on the field (cf), the distance traveled within the field ($D_{cf,mf}$), and the number of times the fertilizer is spread per year (N_f).

$$E_3 = \sum_{cf} \sum_{mf} (EF_{mf} \cdot D_{cf,mf} \cdot N_f) \quad (7)$$

Where:

E_3	=	Emissions of the application of fertilizers (tCO_2e/year)
EF_{mf}	=	Emission factor of the vehicle type or application machinery m (tCO_2e/tonne-km)
$D_{cf,mf}$	=	Distance traveled within the field cf via the vehicle type or application machinery mf for one spread (km)

[52] In cases where the Product Carbon Footprint (PCF) provided by the supplier already includes transport-related emissions, and the project intends to make a claim on transport emission reductions, the project developer must exclude these transport emissions from the PCF value. Transport emissions should then be calculated separately for the project using the methodology's project-specific transport emission calculation approach.

N_f	=	Number of times the fertilizer is spread per year

Note 1: In cases where fertilizers are applied manually (i.e., without fuel-based machinery), and the project developer can provide verifiable evidence of such practice, emissions from field application may be considered negligible and be excluded.

Note 2: In sourcing region level projects, field-spreading emissions are excluded from the emission reduction calculation as they can not be tracked.

(4a) Direct N_2O emissions

This approach is based on equations provided by the IPCC[53].

$$E_{4a} = [(FIN \cdot EF_{in,direct\_N2O}) + (FON \cdot EF_{org,direct\_N2O})] \cdot 44/28 \cdot A \cdot GWP_{N_2O} \quad (7a)$$

Where:

E_{4a}	=	Direct N_2O emissions from managed soils due to fertilizer application (kg CO_2eq)
F_{in}	=	Quantity of inorganic N fertilizer applied (kg N / ha)
F_{org}	=	Quantity of organic N fertilizer applied (kg N / ha) [It should be included only when there is sufficient scientific evidence of its nitrogen content and the related emissions]
$EF_{in,direct\_N2O}$	=	Emission factor for N_2O emissions from N inputs from inorganic fertilizer (kg N_2O-N / kg N input)
$EF_{org,direct\_N2O}$	=	Emission factor for N_2O emissions from N inputs from organic fertilizer (kg N_2O-N / kg N input)
$44/28$	=	Molar mass ratio of N_2O to N applied to convert N_2O-N emissions to N_2O emissions. [It should be applied only when the unit of the reported EF is in kg N_2O-N, rather than kg N_2O]
A	=	Area of the intervention (ha) [54]
GWP_{N_2O}	=	Global warming potential of nitrous oxide (kg CO_2e / kg N_2O) [Based on IPCC AR6, the 100-year GWP for N_2O is 273]

If direct N_2O measurements are in scope as part of the project, that follow approach 2: Direct Measurements and the guidelines outlined in appendix *A.2.3 Quality Criteria of Experimental Design (of studies/trials)*, then those measured cumulative emissions can be used to replace

[53] https://www.ipcc-nggip.iges.or.jp/public/2019rf/pdf/4_Volume4/19R_V4_Ch11_Soils_N2O_CO2.pdf
[54] In case a sourcing region level approach is used, the emissions are calculated based on the total amount of fertilizer product distributed. As such the area of the intervention is not relevant.

emission factor-based calculations and the equation can then be adjusted accordingly (see equation 7b).

The same logic can be applied to the equations of the other activities.

$$E_{4a} = EF_{direct\_N2O\_c} \cdot A \cdot GWP_{N_2O} \tag{7b}$$

Where:

$EF_{direct\_N2O\_c}$	=	Cumulative emissions, derived from the periodic flux measurements which are taken over the growing season, and the values are integrated over time. This integration provides the total N_2O emissions for the monitoring period (kg N_2O/ha)
A	=	Area of the intervention (ha)
GWP_{N_2O}	=	Global warming potential of nitrous oxide (kg CO_2e / kg N_2O) [Based on IPCC AR6, the 100-year GWP for N_2O is 273]

(4b) Indirect emissions originated from ammonia volatilization

$$E_{4b} = [(F_{in} \cdot EF_{in,\,indirect\_NH3} \cdot NH_3\,vol_{in}) + (F_{org} \cdot EF_{org,\,indirect\_NH3} \cdot NH_3\,vol_{org})] \cdot 44/28 \cdot A \cdot GWP_{N_2O} \tag{8}$$

Where:

E_{4b}	=	Indirect N_2O emissions from ammonia volatilization due to fertilizer application (kg CO_2eq)
F_{in}	=	Quantity of inorganic N fertilizer applied (kg N / ha)
F_{org}	=	Quantity of organic N fertilizer applied (kg N / ha) [It should be included only when there is sufficient scientific evidence of its nitrogen content and the related emissions]
$EF_{in,\,indirect\_NH3}$	=	Emission factor for N_2O emissions from volatilized NH_3 originating form inorganic fertilizer (kg N_2O-N / kg NH_3-N volatilized)
$EF_{org,\,indirect\_NH3}$	=	Emission factor for N_2O emissions from volatilized NH_3 originating form organic fertilizer (kg N_2O-N / kg NH_3-N volatilized)
$NH_3\,vol_{in}$	=	Fraction of inorganic N fertilizer that volatilises as NH_3 (kg NH_3-N volatilized)
$NH_3\,vol_{org}$	=	Fraction of organic N fertilizer N that volatilises as NH_3 (kg NH_3-N volatilized)
44/28	=	Molar mass ratio of N_2O to N applied to convert N_2O-N emissions to N_2O emissions [It should be applied only when the unit of the reported EF is in kg N_2O-N, rather than kg N_2O]

A = Area of the intervention (ha)

GWP_{N_2O} = Global warming potential of nitrous oxide (kg CO_2e / kg N_2O)
[Based on IPCC AR6, the 100-year GWP for N_2O is 273]

(4c) Indirect emissions originated from leaching and runoff of N

It should be determined whether leaching emissions are relevant based on soil type, climate, and management practices in the project area.

$$E_{4c} = [(F_{in} \cdot EF_{in,\, indirect\_l} \cdot N\ leaching_{in}) + (F_{org} \cdot EF_{org,\, indirect\_l} \cdot N\ leaching_{org})] \cdot 44/28 \cdot A \cdot GWP_{N_2O} \quad (9)$$

Where:

E_{4c} = Indirect GHG emissions from N leaching/runoff due to fertilizer application (kg CO_2eq)

F_{in} = Quantity of inorganic N fertilizer applied (kg N / ha)

F_{org} = Quantity of organic N fertilizer applied (kg N / ha)
[It should be included only when there is sufficient scientific evidence of its nitrogen content and the related emissions]

$EF_{in,\, indirect\_l}$ = Emission factor for N_2O emissions from N leaching/runoff originating from inorganic fertilizer (kg N_2O-N/kg N leaching/runoff)

$EF_{org,\, indirect\_l}$ = Emission factor for N_2O emissions from N leaching/runoff originating from organic fertilizer (kg N_2O-N/kg N leaching/runoff)

$N\ leaching_{in}$ = Fraction of inorganic N fertilizer that is lost through nitrate leaching and runoff (kg N leached/runoff)

$N\ leaching_{org}$ = Fraction of organic N fertilizer that is lost through nitrate leaching and runoff (kg N leached/runoff)

$44/28$ = Molar mass ratio of N_2O to N applied to convert N_2O-N emissions to N_2O emissions
[It should be applied only when the unit of the reported EF is in kg N_2O-N, rather than kg N_2O]

A = Area of the intervention (ha)

GWP_{N_2O} = Global warming potential of nitrous oxide (kg CO_2e / kg N_2O)
[Based on IPCC AR6, the 100-year GWP for N_2O is 273]

4.3 Uncertainty

To ensure the credibility and conservativeness of emission reduction estimates, this methodology provides two approaches for addressing uncertainty, depending on the tier of data used.

Option 1: LMU type of projects with Tier 3 Data

For field-level (LMU) projects using Tier 3 data, the project developer must conduct a quantitative uncertainty assessment. To do that the tool developed by the GHG Protocol Initiative [55] can be used. This Excel-based tool automates the aggregation steps for developing a basic uncertainty assessment for GHG inventory data, following the Intergovernmental Panel on Climate Change (IPCC) Guidelines for National GHG Inventories. The tool is supplemented by a guidance document [56], which describes the functionality of the tool and gives a better understanding of how to prepare, interpret, and utilize uncertainty assessments. This approach allows for more precise project-specific estimates and may support higher claims when uncertainty is well-characterized and transparently reported.

Option 2: LMU and sourcing region type of projects with Tier 1 or Tier 2 Data

For both LMU and sourcing region types of projects using Tier 1 or Tier 2 data, a simplified, conservative approach must be followed to ensure robustness of estimates:

- **Meta-Analysis Based Factors**: When using meta-analyses to derive emission factors or emission reduction percentages, project developers should combine multiple context-specific variables, such as soil type, crop type, application rate, and product characteristics, to ensure the selected EF (from the EF ranges) is both conservative and grounded in the most relevant evidence. For that purpose 95% confidence interval (CI) must be used.
- **Conservative Parameter Selection**: Project developers must select values from the conservative end of available ranges. Specifically, rather than selecting the absolute minimum of the 95% confidence interval (CI), the chosen value should correspond to a point located 25% of the distance from the mean toward the lower (more conservative) bound of the interval.
- **Regional Deduction**: For sourcing region types of projects, a fixed 5% deduction (as explained in section 2.3 Spatial boundaries) must be applied to the estimated reductions to account for the higher uncertainty associated with aggregated data and absence of field-level monitoring.

This approach provides a practical and reliable framework for uncertainty management in cases where project-specific measurements are not feasible.

[55] https://ghgprotocol.org/calculation-tools-and-guidance
[56] https://ghgprotocol.org/sites/default/files/2023-03/ghg-uncertainty.pdf

5 Net reduction of GHG emissions

The project developer can *estimate* the GHG emission reductions of the project during the crediting period based on the best available data at the time of the validation of the POD.
The issuance of the emission reduction certificates is done on a yearly basis, after updating the project design parameters (see section 6.1 Monitoring), and verifying the GHG emission reduction by a VVB. The *project emissions* and therefore the *net reduction of GHG emissions* are *dynamic* as they can change from year to year, depending on the management practices on the field (e.g., crop cultivated, selected inorganic fertilizer, selected CRF product, nitrogen application rate, etc.).

The GHG emission reduction is defined as the difference between the baseline emissions and the project emissions [57]. To conservatively account for potential leakage, a (potentially reversible) leakage deduction factor is applied to the total net emission reductions. This factor reflects the assessed risk that the project activity may indirectly cause an increase in GHG emissions outside the project boundary, either through market displacement of conventional fertilizers or unintended yield impacts. The applicable leakage deduction is determined based on the classification described in section 1.8 Leakage & permanence.

To calculate the net GHG emissions reduction, the following equation can be used:

$$ER = (BE - PE) \cdot (1 - LP) \cdot (1 - UP) \tag{10}$$

Where:

ER	=	Net GHG emissions reduction (tCO_2e)
BE	=	Baseline emissions (tCO_2e)
PE	=	Project emissions (tCO_2e)
LP	=	Leakage penalty (%). If leakage is reversible, the credited emissions may be adjusted retroactively, or an equivalent amount may be withdrawn from the buffer pool. In either case, the adjustment equals the leakage penalty multiplied by the annual Net GHG emissions reduction.
UP	=	Uncertainty penalty for sourcing region type of projects (%)

The *net GHG emissions reduction* for the entire project is a key metric, representing the total annual reduction in emissions, expressed in tonnes of CO_2e. However, it is equally important to present the impact of the intervention using different metrics that can be used by various stakeholders. Examples of these metrics are presented in Appendix C.

[57] The total baseline or project emissions are calculated by summing the emissions from all activities within the defined scope. The activities in scope are determined by the selected project type and the interventions included. The calculation methods for each activity are described in section 4.2 Equation of each activity step.

6. Monitoring, Reporting and Verification

The MRV process is a structured approach to quantifying, tracking, reporting, and verifying greenhouse gas (GHG) emissions and reductions achieved through the distribution or use of low-emission fertilizers. The goal of the MRV approach is to ensure accurate, consistent, and credible measurement and reporting of emissions over time, enabling the issuance of high-quality emission reduction certificates. The Project Developers must follow the monitoring, reporting and verification (MRV) procedures of the latest version of the Proba Standard [58].

The monitoring plan includes:

- The type of information that needs to be collected
- The evidence for each datapoint
- The frequency of reporting

6.1 Monitoring

For this methodology, the monitoring focuses on collecting three key types of data:

A. **Project scoping:** Key project details defined before the project start, submitted once during the POD validation phase (see *Table 8).*

B. **Project design parameters:** Variables monitored and reported during each verification cycle to ensure compliance and accuracy (see *Tables 9 and 10*). Those must be completed for each specific intervention that is outlined in the project scoping. As seen in *Tables 9 and 10*, the evidence required for these design parameters primarily rely on traditional methods such as farmer logs and market-based assessments. Where feasible, it is recommended to integrate for advanced approaches such as satellite monitoring, IoT sensors, and blockchain-based recordkeeping in regional approaches, to enhance efficiency, accuracy, and transparency. All monitored parameters for each monitoring period must be listed in the following standardized format: a) Data / parameter: , b) Data unit: , c) Description: , d) Source of data: , e) Measurement procedures (if any): , f) Monitoring frequency: , g) QA/QC procedures: , h) Any comment:

C. **Project impact:** Outcomes calculated during each verification cycle (see *Table 11*), based on the monitored project design parameters. Again, the impact must be calculated and presented separately for each intervention in scope.

[58] https://proba.earth/hubfs/Product/The_Proba_standard.pdf?hsLang=en

Table 8: Project scoping

Index	Name	Description	Background from this methodology	Evidence required	Frequency of reporting
A1	Scope of activities	Present list of interventions that are in scope of the project, on the LMU or on the Sourcing Region level	Section 2.1 Scope of activities	N/A	Once during POD validation or update during verification if they change during the crediting period
A2	GHG sources	Explain which GHG sources are in scope of the intervention	Section 2.2 GHG emissions	N/A	
A3	Spatial boundary and size (hectares or similar)	Present coordinates delineating the: • locations of the field (for Land Management Unit level boundary) • boundaries of the region (for Sourcing Region level boundary)	Section 2.3 Spatial boundaries	• Satellite imagery or GIS-based shapefiles or geospatial coordinates • coordinates via national land ownership databases or other proof of ownership	
A4	Temporal boundary (for monitoring)	Define the temporary boundary for the project	Section 2.4 Temporal boundaries	N/A	

Table 9: Project design parameters for Land Management Unit level intervention

Index	Category name	Subcategory name	Description	Evidence required for baseline[59]	Evidence required for project	Frequency of reporting
B1.1	Crop type	-	Type of crop being cultivated	Farmer log or market based information	Farmer log	Reconfirmed or updated for every verification
B1.2	Fertilizer	PCF	Cradle to gate emissions	For the specific requirements see section 4.1 EF-data reference approaches		
		Type	Type of fertilizer (mix) being applied	Market based information or farmer log (historical-regional approach, see 3. Baseline scenario)	Proof of purchase and product label	
		Nut-rate	Nutrient application rate (NPK) in each fertilizer	Market based information or farmer log (historical-regional approach, see 3. Baseline scenario)	Fertilizer product description (f.i. label or safety data sheet)	
		Application rate & method	Application rate of the fertilizer(s) & method, timing, splitting	Farmer log or market based information	Farmer logs detailing actual application dates, rates, and area covered for each fertilizer applied. If Nut-rate reduction is part of the intervention, also supply scientific evidence.	
B1.3	Crop yield	-	Amount of crops harvested	Farmer log or market based information	Proof of crop yield productivity (e.g., crop insurance reporting records)	
B1.4	NutUE	-	Nutrient use efficiency, which must be compared to historical or regional benchmark NutUE values to verify that the baseline practices are following the	Market based information or farmer log (historical-regional approach, see 3. Baseline scenario)	Calculated based on crop yield and Nut-rate	

[59] As described in section 3. Baseline scenario, the baseline is dynamic and must be updated as per the baseline guidelines.

Index	Category name	Subcategory name	Description	Evidence required for baseline[59]	Evidence required for project	Frequency of reporting
			region's guidelines			
B1.5	Transportation emissions	Distance	Average distance between the production location and the use location of the fertilizer	Data from distributor	Data from distributor	
		Vehicle type	Type of vehicle(s) used to transport the fertilizer	Data from distributor, industry reports	Data from distributor, industry reports	
B1.6	Field spreading emissions	Machinery type	Type of vehicle(s) used to spread the fertilizer	Farmer log	Farmer logs related to days of application	
		Distance traveled per field spread	Distance that the machinery (e.g. tractor) travels to spread the fertilizer	Farmer log	Farmer logs related to days of application	
		Number of field spreading events per cropping cycle	Based on the type of fertilizer, spreading method, etc. different number of field spreading events might happen.	Farmer log	Farmer logs related to days of application	
B1.7	(Optional) Additional management practices	-	Optional only if additional management practices are implemented, along with the low-emission fertilizer, which lead to an extra reduction of GHG emissions	-	• Scientific evidence of the emission factor, that is related to this intervention • Proof that the additional practice actually took place (remote sensing, video imagery, farmer log, or similar)	
B1.8	Emission factors	-	List of EFs selected for each activity in scope. Source, justification, and tier (1–3) of all EFs used in calculations	For the specific requirements see section 4.1 EF-data reference approaches		

Table 10: Project design parameters for Sourcing Region level intervention

Index	Category name	Subcategory name	Description	Evidence required for baseline	Evidence required for project	Frequency of reporting
B2.1	Crop types (if applicable)	-	The types of crops grown in the region, allowing emissions to be weighted based on the proportion of total cultivated hectares for each specific crop	Regional databases / sources	Regional databases / sources	Reconfirmed or updated for every verification
B2.2	Fertilizer	PCF	Cradle to gate emissions	For the specific requirements see section 4.1 EF-data reference approaches		
		Types	Types of fertilizer mix being applied on the region	Market based information (historical-regional approach, see 3. Baseline scenario)	Proof of sale (or purchase) of fertilizer	
		Nut-rate	Nutrient application rate in each fertilizer (if applicable)	Market based information (historical-regional approach, see 3. Baseline scenario)	Proof of sale (or purchase) of fertilizer	
		Application rate [60]	Average application rates of the fertilizers (if applicable)	Regional databases / sources	Regional databases / sources	
B2.3	Crop yield	-	Average crop yields (for NutUE check) (if applicable)	Regional databases / sources	Farmer log or sale proof from a representative sample of farmers	
B2.4	NutUE	-	For transparency purposes it is recommended to present the relevant (to the project interventions) NutUE of the region	Regional databases / sources	Calculated based on crop yield and average application rates	

[60] Not always necessary for Sourcing region *a. Fertilizer production emissions reduction* type of projects. See section 3. Baseline.

Index	Category name	Subcategory name	Description	Evidence required for baseline	Evidence required for project	Frequency of reporting
B2.5	Transportation emissions	Distance	Average distance between the production location and the use location of the fertilizer	Data from distributor	Data from distributor	
		Vehicle type	Type of vehicle(s) used to transport the fertilizer	Data from distributor, industry reports	Data from distributor, industry reports	
B2.6	Emission factors	-	List of EFs selected for each activity in scope. Source, justification, and tier (1–3) of all EFs used in calculations	For the specific requirements see section 4.1 EF-data reference approaches		

Table 11: Project impact (for LMU or Sourcing Region type of projects intervention)

Index	Category name	Subcategory name	Calculation method	Frequency of reporting
C1.	Net reduction of GHG emissions	-	Section 5. Net GHG emissions reduction	Updated every verification
C2.	Different metrics of GHG emissions	Per unit of land area	Appendix C: Different metrics of GHG emissions	
		Per unit of crop produced		
		Per unit of nitrogen containing fertilizer applied		

6.2 Reporting

To ensure transparency and accountability, monitoring reports must contain:

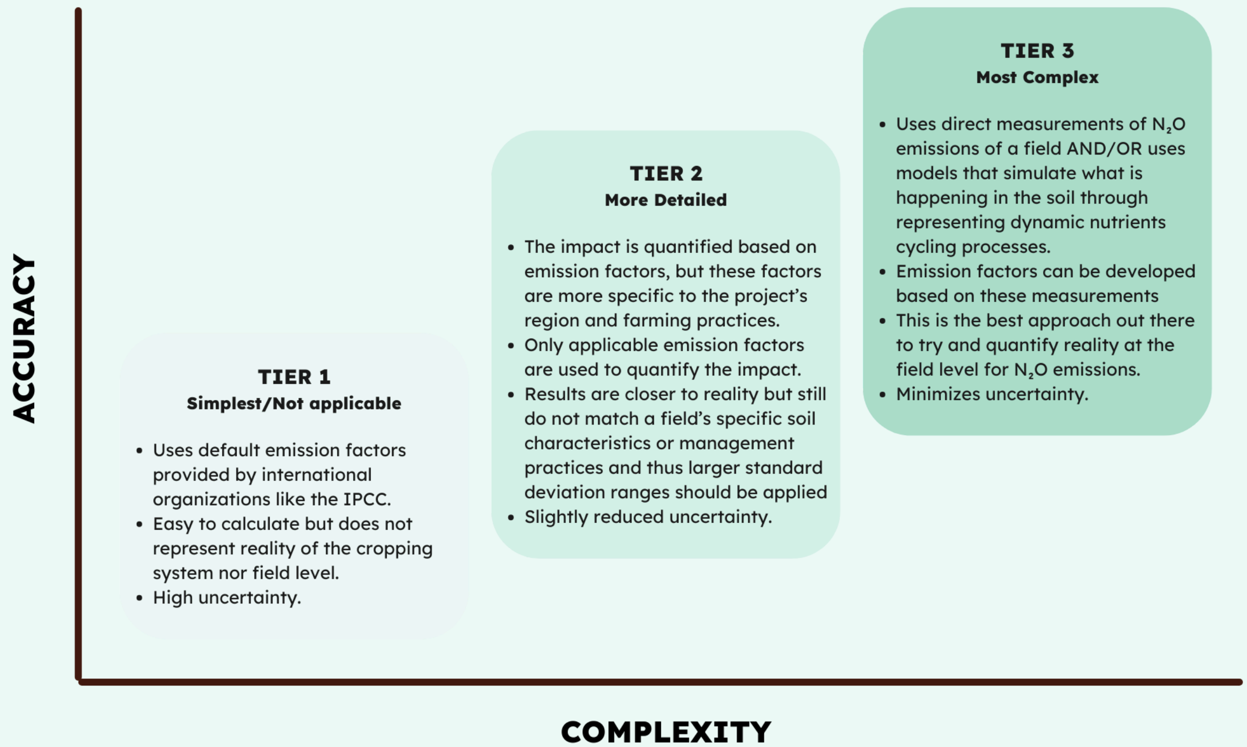
- A general description of the project:
  - For LMU type of projects: the location and outline of individual fields where the fertilizer products would be applied and baseline emissions would have occurred.
  - For sourcing region type of projects: the defined regional boundary and the aggregate intervention area across the sourcing region.
- A description of the data collection process, frequency of monitoring, and procedures for archiving data, as presented in section 6.1 Monitoring. Note that in this methodology the baseline is dynamic and must be updated according to section 3. Baseline scenario.
- A recordkeeping plan to maintain accurate documentation that shows when and where fertilizer application has occurred:
  - For LMU type of projects: This includes field records, field investigations, farm implementation measures, machinery receipts, delivery notes and/or invoices
  - For Sourcing Region type of projects: This includes fertilizer product distribution data, regional sales volumes, or aggregation of application reports from participating cooperatives or farming associations
- The roles of individuals involved in monitoring and data collection (e.g., responsibilities).
- Monitoring reports must be submitted once per temporal boundary (see 2.4 Temporal Boundaries).
- The monitoring time period must be documented in every report.
- All monitoring reports must be accessible at the demand of the Validation, Verification Bodies (VVB) for validation and verification procedures.

6.3 Verification

An approved Validation and Verification Body (VVB) must be selected to execute the verification process based on the monitoring plan and reports to confirm that the program's requirements are met, ensuring the accuracy of the calculated GHG reductions resulting from the use of low-emission fertilizers. Information regarding the frequency of the verification process can be found in the Proba Standard. No additional requirements for site inspections are prescribed for this methodology. The project developer must define a proper site inspection plan in the POD. It is acknowledged that most of the critical variables, like crop type, fertiliser rate and yield, rely heavily on farmers logs and market-based information. Project developers must transparently define a verification plan in collaboration with the VVB to ensure that key variables, particularly fertilizer rate and crop yield, are accurately represented. This plan must outline how critical claims will be substantiated using independent or verifiable data sources where applicable. The verification approach must be documented in the POD and implemented during the verification period.

Appendix A: Emission factor description and usability

A.1 Tier definitions



Tiers 1, 2, and 3 represent progressively detailed approaches for quantifying emissions related to fertilizer use (baseline) and during the application of low in-field emission products (project), suitable for different levels of data availability and analysis precision:

- **Tier 1** is the most generic approach, utilizing global default EF for generalized estimates. It relies on broad quantification with minimal data requirements (e.g., IPCC 2019 tables). Tier 1 is only applicable in this methodology for estimating direct and indirect N_2O emissions in cases where no project-specific or region-specific (Tier 2) data are available.
- **Tier 2** EF can be derived from existing meta-analyses, systematic reviews, EF databases or scientific literature. This approach allows for more accurate quantification of emissions associated with both the baseline fertilizer application and the intervention using low-emission fertilizer products. Empirical equations are used, with contextualized EF reflecting to the highest potential possible the agricultural practices, soil types, and

environmental/climatic conditions of a particular area. Detailed procedures and guidelines of how to select appropriate EF is discussed below.

- **Tier 3** represents the most detailed and accurate approach, relying on either advanced biogeochemical process-based modeling[61] or site-specific data collection through field measurements during the project implementation. This tier quantifies emissions related to baseline fertilizer use and low-emission fertilizer products application by incorporating site-specific data, such as soil properties, actual site precipitation and temperature data, timing of specific practices (e.g., planting, fertilization, irrigation, harvesting), and crop yield.

  Field-based data collection, including direct N_2O measurements (e.g., via static chambers), fertilizer inputs, crop yield outputs, and associated environmental variables such as soil moisture, temperature, and pH, can provide high accuracy and credibility to the reduction claims.

A.1.1. Prioritization of EF sources and Tiers

- Priority should be given to Tier 3 (site-specific data or field measurements) whenever such data is available. If a project developer does not use this tier, they must explain why a more granular approach was not feasible. As such, EF Approach 1 should be followed (see section 4.1 EF-data reference approaches).
- Tier 2 should be used when Tier 3 data is unavailable, and the available literature or scientific data provides sufficient relevance to estimate emissions accurately (see section A.2.1 Alignment with the key environmental factors and management practices). As such, EF Approaches 1 and 3 are the next best options.
- Tier 1 can be used when neither Tier 2 nor Tier 3 data is available. In such cases, Tier 1 emission factors must be chosen based on the disaggregation options that are provided by IPCC and may be used to estimate the baseline emissions. For estimating the project's impact an emission reduction percentage which is derived from scientific literature or meta-analyses, must be applied.
- If there is a lack of scientific literature or data related to the intervention or region, the project cannot make a claim about emission reductions, as this methodology is based on a science-driven approach.

[61] The use of process-based models for deriving the Emission Factors is not eligible in this version of the methodology.

A.2 Emission factor selection criteria based on scientific studies

A.2.1 Alignment with the key environmental factors and management practices

- Scientific studies used for deriving EFs must align as closely as possible with the project's geographical and agricultural context. This ensures that the baseline and project emissions reflect realistic, applicable, and relevant conditions. However, it is recognized that full alignment may not always be possible. In such cases, project developers must apply conservative assumptions and clearly document their justification as described in section 4.3 Uncertainty. Key criteria must include:
  - **Environmental factors:** The study must be conducted in a location with environmental conditions similar to the project area. The most influential environmental variables should be prioritized, based on relevance.
  - **Management practices:** The study must involve management practices that match the baseline and project interventions, such as:
    - Fertilizer type
    - N application rate
    - Use of the same category of fertilizer product
    - Crop type
  - If there is only partial alignment, project developers must adopt a conservative EF and document the rationale for its selection.
  - The low-emission fertilizer products used in the study must follow the criteria mentioned in section 1.3 Eligible products and be commercially available.
  - **Temporal relevance:** The studies that EF are retrieved from should be recent enough to reflect current climatic conditions, agricultural technologies and practices. A common practice is to utilize studies published within the last 30 years, provided there have been no significant changes in agricultural practices, technologies or climatic conditions (due to climate change) in the region. If such changes have occurred, more recent studies (e.g., within the past 10 years) should be considered, in order to accurately reflect the current conditions.
- Where this alignment is demonstrated, even a single study may be leveraged to generate the EF applied at the project or baseline level. However, this methodology recommends that at least 2 studies are used for the EF selection, to make sure that the EF is representative. In case multiple studies are used, then an average of the EFs must be used to derive the EF.

A.2.2 Utilization of meta-analyses papers

Meta-analyses papers can serve as valuable sources for EF extraction as it is described in section 4.1 EF-data reference approaches, provided they meet specific quality criteria:

- **Heterogeneity:** Meta-analyses must report or assess heterogeneity (I^2) among studies. If I^2 is not provided, developers must provide evidence of variability (e.g., range, SD, forest plot) and justify reliability. If high heterogeneity is evident (e.g., I^2 > 75% or clear visual spread), an uncertainty buffer of 10% must be applied unless justified via subgroup analysis.
- **Representation of diversity**: The meta-analysis must include studies with diverse environmental and management conditions. It should provide distinctions based on factors such as regions, soil types, or other relevant characteristics that can be correlated to the project's specific conditions.
- **Study alignment**: Each individual study within the meta-analysis must adhere to the project's regional, temporal, and management relevance criteria. The meta-analysis should offer a clear breakdown of data categorized by region, soil type, or other variables to enable alignment with the project's characteristics.
- **Data extraction**: When a meta-analysis provides average EFs, in order to use them project developers must ensure that these averages align with their project's specific characteristics, including environmental factors and management practices as mentioned in section A.2.1. If the provided averages do not sufficiently match the project's conditions, wherever feasible, project developers should extract raw data from the meta-analysis and create new averages that better reflect the project's specific context. In such cases, detailed documentation of the procedure must be provided to ensure transparency and traceability.
- **Uncertainty consideration**: Each average EF must be accompanied by its reported average standard deviation. Meta-analyses must report standard deviations (SDs) or confidence intervals for derived average EFs. An additional uncertainty penalty must be applied if raw data is unavailable or if inclusion criteria for individual studies are unclear.

A.2.3 Quality criteria of experimental design (of studies/trials)

The robustness of the experimental design is critical to ensure that the EF values derived are reliable and reproducible. To achieve this, the following criteria must be met:

- **Temporal coverage and measurement period:** Scientific studies often recommend a two-year temporal coverage to account for year-to-year variability in environmental conditions. However, due to practical limitations, a one-year experiment is also acceptable, provided that more plot-level replications (e.g., multiple experimental units under different conditions) are included to strengthen reliability and improve data robustness. The duration measurement period should align with the crop cycle and seasonal variations to ensure comprehensive data. Emissions should be measured over a period that captures all significant nitrogen loss events, including heavy rainfall, drought, or temperature fluctuations, if they occurred. For fertilizers with extended nutrient release characteristics, it is recommended to extend the measurement period post-harvest to capture potential lagged N_2O emissions.

- **Replication**: A minimum of three replicates per treatment is required (Abalos et al., 2014; Fan et al., 2022) to account for variability in environmental and management conditions. A lack of replication may undermine the reliability of the results.
- **Controls**: The experiment must include treatment without the low-emission fertilizer products (baseline) and a control without nitrogen fertilizer application.
- **Standardized measurements**: Emissions must be quantified using scientifically recognized methods. For instance, chamber-based measurements for direct N_2O emissions or isotopic techniques for tracking nitrogen transformations.
- **Consistency across treatments**: Environmental and management conditions (e.g., fertilizer application rates, irrigation) must be consistent across treatments (control and intervention) to ensure comparability. Differences in these conditions can skew results and reduce the validity of derived EFs.
- **Data reporting**: Studies must clearly present key information, including:
    - Mean cumulative N_2O emissions (direct and/or indirect) for control and treatment groups
    - EF for each treatment
    - Fertilizer product type, application rate
    - Associated uncertainty ranges (e.g., standard error)
    - Environmental conditions (e.g., soil texture, rainfall, air or soil temperature)
    - Number of replicates
- **Field-based measurements**: Measurements must be conducted under field conditions. Measurements reported from laboratory experiments are not considered applicable for this methodology.

For in-field measurements, project developers must adhere to the relevant guidelines to ensure that field measurements are conducted rigorously and provide data that meet the quality standards required to provide emissions from the field and eventually Tier 3 EF to be developed. An example is the Lyons et al., (2024b) study "*Field Trial Guidelines for Evaluating Enhanced Efficiency Fertilizers*".

Appendix B: Uncertainty Factor calculation

The uncertainty factor of the data depends on the source and quality of the data, which leads to different calculation methods for data collected from different sources.

B.1 Uncertainty propagation for single-source data

The overall uncertainty in the net GHG emission reduction can be derived by combining the uncertainties from both the baseline and project emissions. This can be done using the following propagation of uncertainty formula:I

$$UF = \sqrt{(\sigma_{BE})^2 + (\sigma_{PE})^2 - 2 \cdot \sigma_{BE\,PE}} \quad (11)$$

Where:

UF_i	=	Uncertainty of source i (source i can refer to literature i /field plot i, etc.)
σ_{BE}	=	uncertainty in the baseline emissions (%)
σ_{PE}	=	uncertainty in the project emissions (%)
$\sigma_{BE\,PE}$	=	covariance between the uncertainties of the two values (if they are correlated). Since the baseline and project emissions are independent (no correlation between them), the covariance is typically considered zero.

B.2 Uncertainty propagation of multi-source data

When combining EF from multiple sources into one, the following equation can be used:

$$UF = UF_{avg} = \frac{\sqrt{\sum_{i=1}^{n} UF_i^2}}{n} \tag{12}$$

Where:

$UF = UF_{avg}$	=	will be the Uncertainty Factor (%) used in calculating the actual GHG emissions reduction, which is the average of the uncertainties in the relevant data from all the from 1 to n sources
UF_i	=	Single-Source Uncertainty Factor of source i
n	=	number of independent Single-Sources that have similar conditions to the actual project being implemented

Appendix C: Different metrics of GHG emissions

A commodity-based approach for quantifying the impact is particularly relevant for downstream stakeholders. For example, a food company may want to use this data for their Product Carbon Footprint (PCF) reports or Life Cycle Assessments (LCAs), where the GHG emissions per tonne of crop is crucial. For a fertilizer producer, the focus may be on the GHG emissions per tonne of fertilizer product applied (again for the cradle-to-grave PCF/LCA), while for a farmer, the GHG emissions per hectare might be more relevant. In Table 12 the key metrics that can be applied are presented. These must all be reported, where possible [62], to enable transparent comparisons.

Table 12: Metrics that can be used for the project GHG emissions

Metric	***Description***	***Example***	***Unit***
Per unit of crop produced **[PCF of crop]**	This metric correlates emissions reductions to crop yield, making it valuable for assessing GHG emissions throughout the food supply chain. By expressing emissions reductions relative to the amount of crop produced, it helps food companies track improvements in sustainability while lowering their carbon footprint. This approach directly links emission reductions with crop yield.	Companies within the food industry (such as food producers) can use this metric to demonstrate that the production of their crops are associated with lower emissions	tCO_2e / ton of crop
Per unit of nitrogen-containing fertilizer applied **[PCF of fertilizer]**	This metric demonstrates the emissions reductions achieved per ton of nitrogen fertilizer applied, providing insight into the efficiency of nitrogen use. It directly quantifies the impact of improved fertilizer management strategies, and demonstrates how much emissions are saved for every kilogram of fertilizer used.	Fertilizer companies looking to show progress in nitrogen use efficiency and claim reduction in their Scope 3 emissions.	tCO_2e / ton of fertilizer

[62] As mentioned in section 3. Baseline scenario, for projects implementing the sourcing region approach with intervention type *a. Fertilizer production emissions reduction* it is not necessary to report the baseline crop type. For this case, the only metric that is relevant is “Per unit of nitrogen-containing fertilizer applied”. If the project developer wants to attribute the emission reduction to a crop, then a crop type and Nut-rate baselining must be done, which will allow the quantification of the other metrics.

Per unit of land area	This metric provides clear insights into GHG emissions reductions on a field level. By quantifying emissions reductions per hectare, this metric allows for direct comparison between different fields or farms, making it critical for broader environmental claims.	Companies within the food industry (such as food producers) can use this metric to demonstrate that the production of their crops are associated with lower emissions	tCO_2e / ha

To showcase the impact of the project intervention, these metrics can be compared against the metrics for each of two baseline approaches (see section 3 Baseline scenario).

The quantification of the emissions derived from this methodology, can be directly used by supply chain participants as an input for the Product Carbon Footprints (PCFs) of the crops.

When calculating the **impact per tonne of crop produced** (for the PCF of the crop), it is essential to account for variations in annual crop yield, which can be heavily influenced by external factors such as weather patterns, pests, or regional events. These fluctuations may not accurately reflect the impact of the intervention itself but instead represent broader external trends. To address this, a normalization process is recommended, such as using a moving average for the crop yield.

A **moving average** is a statistical method used to smooth out short-term fluctuations and highlight longer-term trends by creating a series of averages from subsets of data points. Mathematically, it is a type of convolution, where the crop yield data is combined with a filter function, in this case, a simple averaging filter (sometimes referred to as a "boxcar filter"). For a moving average, this filter computes the mean of crop yields within a fixed window size (e.g., 3–5 years). For crop rotation scenarios, only the years with the same type of crop are relevant for each moving average. The window shifts forward through the data series, excluding the oldest value and including the next, producing a smoothed trend line.

This approach effectively reduces the noise caused by year-to-year variability, allowing for a clearer understanding of the intervention’s impact. By comparing the normalized yields with the farmer log and regional baseline scenario, stakeholders, such as (downstream) reporting companies, can better distinguish the intervention's true contribution to emission reductions from region-wide external factors. Additionally, reporting **both** the raw and smoothed yield data provides transparency and ensures that all stakeholders involved understand the normalization process.

Appendix D: Different NutUE metrics

Nutrient Use Efficiency (NutUE) is a crucial metric to evaluate how effectively nutrient (Nut) inputs are converted into agricultural outputs. It plays a key role in both productivity and environmental sustainability, and forms a critical part of assessing the baseline conditions, potential leakage, and intervention effects in low-emission fertilizer technologies projects. While numerous definitions of NutUE exist, this methodology adopts a practical approach by recognizing a core set of indicators, which can be used individually or in combination, depending on data availability and project context. These metrics have been adapted from the definitions and framework proposed by the Sustainable Plant Nutrition Responsible Practices Network (SPRPN) in their 2024 issue brief “Defining Nutrient Use Efficiency in Responsible Plant Nutrition[63]

NutUE indicator	*Description*	*Calculation*	*Unit*	*Practicality*
Partial Factor Productivity (PFP)	Yield of crop harvested per unit of fertilizer nutrient applied.	$PFP = Y/Nut$ Where: $Y = reported\ crop\ yield$ $Nut = Nutrient\ application\ rate$	kg crop/kg Nut	[Must be measured and must be reported in every project] Highly practical, easy to calculate from standard or reported crop yield and Nutrient rate application data.
NUE based on soil surface outputs and inputs (NUEpb)	Ratio of total nitrogen output (harvested) to total nitrogen input. Indicates system-level nitrogen use efficiency.	$NUEpb = R/(Nut + M + B + D)$ Where: $R = Total\ nitrogen\ removed\ in\ harvested\ crop\ bioma$ $N = Nitrogen\ application\ rate$ $M = N\ from\ manure\ or\ organic\ amendments$ $B = N\ from\ biological\ fixation$ $D = Atmospheric\ deposition\ of\ reactive\ nitrogen$	Fraction or %	Comprehensive but data-intensive. It is related to a more detailed analysis at research or institutional level.
Nutrient Balance (NUEfg)	Difference between N inputs and N	$NUEfg = U/(N + M + B + D)$	kg N/ha	Requires full N input/output accounting. It is challenging for

[63]https://sprpn.org/wp-content/uploads/2023/08/Issue-Brief-04_English.pdf

	outputs. Indicates potential for environmental losses.	Where: $U = Nutrient\ uptake\ in\ crops\ or\ final\ product$ $N = Nutrient\ application\ rate$ $M = Nutrient\ from\ manure\ or\ organic\ amendments$ $B = Nutrient\ from\ biological\ fixation$ $D = Atmospheric\ deposition\ of\ reactive\ nitrogen$		most farmers but useful for environmental assessments.
Agronomic Efficiency (AE)	Increase in crop yield per unit of Nutrient applied compared to untreated control. Reflects crop gain efficiency from fertilizer.	$AE = (Y - Yo)/Nut$ Where: $Y = reported\ crop\ yield$ $Yo = crop\ yield\ from\ unfertilized\ plot$ $Nut = Nutrient\ application\ rate$	kg crop/kg Nutrient	Less practical, it requires untreated control plots, which may be hard to implement widely.
Recovery Efficiency (RE)	Proportion of applied Nutrient that is taken up by the crop. Indicates the effectiveness of Nutrient uptake.	$RE = (U - Uo)/Nut$ Where: $Uo = Nutrient\ uptake\ in\ crop\ from\ unfertilized\ plot$ $U = Nutrient\ uptake\ in\ crop\ from\ fertilized\ plot$ $N = Nutrient\ application\ rate$	Fraction or %	Less practical, it requires plant Nutrient uptake data or lab analysis and control plots, which may be hard to implement widely.

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