ANL AGRO NEW LIFE

ANL01

Carbon Project Methodology from Native Vegetation Areas and Perennial Crops in Rural Properties

Version 2.1

September 2025

Methodology for the development of carbon projects of the insetting, offsetting type, or for the generation of financial assets such as the Green CPR (CPR Verde), based on the conservation and restoration of native vegetation areas and the sustainable management of long-term perennial crops on rural properties. The methodology includes the quantification of greenhouse gas (GHG) emissions, carbon stocks, and carbon removals across the entire property boundary, together with monitoring, reporting, and verification (MRV) plans conducted by third parties. Projects remain eligible even in the absence of perennial crops.

VERSION 2.1
September 2025

This version 2.1 of the Methodology for Carbon Projects in Native Vegetation Areas and Perennial Crops on Rural Properties — previously entitled “ANL01 PES Carbon Methodology (v1.0)” — was developed by Agro New Life and incorporates improvements resulting from the public consultation carried out between June and July 2025 and from the methodological review conducted by FoodChain ID in March 2025.

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1. EXECUTIVE SUMMARY

Despite Brazil's vast ecological wealth and advances in conservation legal frameworks, rural landowners remain widely excluded from carbon markets due to the lack of methodologies suited to their reality. Areas of native vegetation—pillars of environmental integrity—are maintained at their own expense, without remuneration for the ecosystem services they provide to society (climate regulation, carbon storage, water cycle, biodiversity, erosion control). Under most current methodologies, these services are still neglected or underestimated.

This methodology was developed to fill that gap. It adopts the entire farm as the accounting unit, focusing on the net carbon balance at the property level, with modular and traceable accounting. To this end, it integrates emissions from all activities carried out on the farm, carbon removals by native vegetation and by perennial crops, and carbon stocks in native vegetation already conserved and eligible.

Unlike approaches focused solely on additional removals or avoided deforestation, this methodology recognizes, in a verifiable manner, the carbon stocks already maintained in standing forests and makes their remuneration conditional on the annual maintenance of ecological integrity. At the same time, the methodology recognizes the long-term sequestration of long-lived perennial systems (coffee, citrus, cocoa, rubber, and others) and integrates it into the project's net greenhouse gas (GHG) balance, with explicit deduction of management-related emissions, such that only the annual net surplus is eligible for credit issuance.

To enhance transparency and replicability, Monitoring, Reporting and Verification (MRV) prioritizes auditable remote sensing, with annual updates and consistent time series. Monitoring is annual and must result in a report delivered at the end of each year, assessing all changes in emissions, removals, and stocks, including biogenic flows; only after this verification may credits be generated. Credit cycles are five years in length, with periodic baseline re-assessment, where verified reversals result in proportional deductions.

The modular architecture enables use in offsetting (tradable credits), insetting (mitigation within the supply chain), and in the issuance of financial instruments backed by environmental assets—such as the *Cédula de Produto Rural Verde* (CPR Verde), a Brazilian credit note backed by environmental assets. Safeguards against double counting apply in all modalities. In insetting, cross-module compensation ("netting") is prohibited, understood as: (i) using reductions or removals from one module/scope to neutralize increases in another (for example, employing biogenic removals from perennials to offset fossil emissions in transport/processes, or using energy reductions to compensate increases in livestock); (ii) double claiming of the same result (e.g., reporting it as insetting and simultaneously as an offsetting credit); and (iii) intertemporal compensation between periods to mask deficits, that is, using reductions verified in one year to neutralize an emissions increase in another year. Reporting remains segregated by module, scope, and category (reductions vs. removals; biogenic vs. fossil). Still for insetting, the Project Design Document (PDD) must demonstrate traceability (chain of custody) and identify, at a minimum, the first recipient—that is, who receives the first delivery of the product/service linked to the result (for example, a cooperative, a warehouse, or a distribution center)—with documentation that enables tracing the batch to the final recipient of the insetting claim.

Adopting a whole-farm system boundary reduces leakage risk and improves traceability, aligning incentives to conserve, manage, and produce with lower emissions intensity. Conservative uncertainty discounts and risk-buffer mechanisms reinforce environmental integrity.

Additionality is anchored in the national legal frameworks of the Brazilian Greenhouse Gas Emissions Trading System (SBCE, Law No. 15,042/2024) and the National Policy on Payment for Environmental Services (PNPSA, Law No. 14,119/2021), guiding the assessment of the prolonged conservation of natural ecosystems—which harbor biodiversity (fauna and flora) and provide essential ecosystem services to society, such as climate regulation, maintenance of the hydrological cycle, erosion control, and habitat provision. This conservation is considered additional for occurring on rural properties subject to recurrent risks of degradation, deforestation, and fire, in addition to climate vulnerability and regional forest deficit, which reinforces its regulatory legitimacy.

In coherence with these frameworks (SBCE/PNPSA), the methodology observes principles of the Integrity Council for the Voluntary Carbon Market (ICVCM) and is compatible with corporate reporting—Greenhouse Gas Protocol (GHG Protocol) and Science Based Targets initiative (SBTi), including the Forest, Land and Agriculture (FLAG) guidance. In practice, it brings climate finance closer to small and medium producers, values what already exists—not only what can be planted—and enables turning conservation and responsible production into recurring, evidence-based revenue.

2. SOURCES

This methodology references the following documents, guidelines, and tools:

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CDM AR-TOOL02. *Combined tool to identify the baseline scenario and demonstrate additionality in A/R CDM project activities.* Version 1.0, EB 35 Annex 19.

CDM AR-TOOL15. *Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities in A/R CDM project activity.* Version 2.0, EB 75 Annex 28.

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ReSeed. *ReSeed Benchmarking White Paper V1.1.* 2024. Available at: https://reseed.farm/wp-content/uploads/2024/06/ReSeed-Benchmarking-White-Paper-V1.1.pdf

Science Based Targets Initiative (SBTi). *Forest, Land and Agriculture (FLAG) Science-Based Target-Setting Guidance.* Version 1.0, 2022.

Social Carbon *SCM0003*: *Methodology for Carbon Removal in Private Conservation Areas.* 2024.

Verra. *VM0007: REDD+ Methodology Framework (REDD-MF).* Version 1.6.

Verra. ***VM0015:*** *Methodology for Avoided Unplanned Deforestation.* Version 1.3.

3. JUSTIFICATION AND METHODOLOGICAL REPOSITIONING

In recent years, technical and scientific institutions have reinforced the need to adapt carbon methodologies applied to the land use, forests, and agriculture sector (AFOLU – Agriculture, Forestry and Other Land Uses) to the realities of tropical countries, where this sector concentrates the majority of emissions (IPCC, 2022; FAO, 2020). In Brazil, gross AFOLU sector emissions accounted for 74% of the national total in 2023 (46% Land-Use Change and Forestry + 28% Agriculture), with the conversion of native vegetation as one of the main sources (SEEG, 2023). This context highlights the need for structural changes in climate finance mechanisms directed at rural properties.

The scarcity of AFOLU methodologies and standards that are scientifically robust to quantify the benefits of conservation and restoration activities—with approaches proportional to project scale, harmonized, and operational—and that are applicable to the reality of small and medium-sized properties limits the effective participation of these actors in climate finance mechanisms (Ecosystem Marketplace, 2022). At the same time, these producers are among the most exposed to the impacts of climate change, which reveals a structural bias that undermines principles of equity and effectiveness in the global climate agenda.

Historical inadequacy of counterfactual models for the AFOLU sector

A large part of climate methodologies applied to the AFOLU sector derives, directly or indirectly, from structures developed under the Clean Development Mechanism (CDM), established by the Kyoto Protocol (1997). In this model, project eligibility depends on proving counterfactual additionality—that is, demonstrating that climate benefits, such as emissions reductions or carbon sequestration, would not occur in the absence of the intervention financed by the credits generated (UNFCCC, 2001; Gillenwater, 2012).

Although this model has proven functional in the energy and industrial sectors—where the adoption of cleaner technologies can, in fact, be conditioned on financial incentives—its direct transposition to the AFOLU sector has revealed structural weaknesses. Unlike industrial emissions—concentrated, technological, and relatively well measurable—emissions and especially removals in AFOLU are influenced by high spatial and temporal variability (soils, climate, moisture regimes, seasonality, and natural disturbances such as droughts, fires, and floods). This multiplicity of factors, varying over short distances and over time, makes it difficult to construct robust and auditable counterfactual scenarios. Added to this are intrinsic challenges such as baseline uncertainty and disproportionate MRV costs in dispersed contexts, which make inherited models—conceived for more homogeneous contexts—prone to fragile estimates in the AFOLU sector (Angelsen et al., 2018; Houghton & Nassikas, 2017).

Furthermore, the different dynamics and complexities associated with land-use emissions and removals reduce the applicability of central criteria such as regulatory surplus—that is, demonstrating that proposed actions exceed legal requirements. In the energy–industrial sector, this criterion is relatively straightforward: emission limits, minimum technological standards, or clearly defined regulatory obligations allow an objective comparison between the projected scenario and regulatory compliance, enabling the creation of baseline parameters replicable across multiple jurisdictions with high technical predictability.

In the Brazilian context, the Forest Code (Law No. 12.651/2012) establishes mandatory safeguards (Legal Reserve – RL and Permanent Preservation Areas – APP) that, depending on biome and location, require the maintenance of substantial fractions of the property—typically between 20% and 80%—under native vegetation. Requiring, as a condition of climate eligibility, results that systematically exceed these legal floors tends to make rural properties economically unviable and to exclude projects that preserve large stocks already protected by law.

In the Brazilian context, the Forest Code (Law No. 12,651/2012) establishes mandatory safeguards—Legal Reserve (*Reserva Legal*) and Permanent Preservation Areas (*Áreas de Preservação Permanente*, APP)—which, depending on the biome and location, require that substantial portions of a property—typically between 20% and 80%—be maintained under native vegetation. Requiring, as a condition for climate eligibility, outcomes that systematically exceed these legal floors tends to render rural properties economically unviable and to exclude projects that conserve large stocks already protected by law. In this context, the literal application of regulatory surplus misaligns the additionality criterion with the reality of Brazilian AFOLU by disregarding the materiality and risk of existing stocks and the need to recognize their long-term conservation.

This misalignment becomes even more evident when considering the asymmetry of permanence between sectors: in energy–industrial contexts, emissions reductions tend to be stable after technological adoption (for example, fuel switching, adoption of best available technologies, and implementation of carbon capture systems), producing trajectories with high predictability. In AFOLU, in turn, 50–100-year horizons often result in speculative extrapolations about future stocks and rates. Therefore, shorter, renewable project cycles with annual monitoring and periodic baseline reassessments tend to be much more effective. This structure not only strengthens traceability and environmental integrity but also establishes the condition that credits can only be generated after the annual verification of observed emissions, removals, and stocks. This arrangement enables gradual, auditable adjustments as new empirical evidence accumulates. It also reduces reliance on long-range projections, anchors credit issuance in updated observations, and improves the traceability of results. At the same time, in the Brazilian context, permanence in AFOLU is further reinforced by the legal regime of the Forest Code—given that RL and APP impose continuous protection over extensive fractions of properties—which intrinsically increases the durability of carbon storage compared with contexts lacking equivalent legal safeguards.

Limitations of the focus on avoided deforestation and reforestation in defining additionality

Although functional in contexts of accelerated conversion, the exclusive focus on avoided deforestation and reforestation restricts the determination of additionality in AFOLU. By treating deforestation as the only disruptive event, conventional methodologies fail to recognize significant emissions in forests that remain “standing” but are under continuous degradation, with losses of carbon, biodiversity, and functionality over time.

Among the multiple factors, selective logging, burning, and soil compaction stand out—pressures that can be mitigated at the farm scale when there are incentives and financial capacity. The evidence is robust: between 2001 and 2018, emissions in the Amazon arising from degradation were comparable to those from total deforestation (Lapola et al., 2023). Up to 70% of emissions in tropical forests may result from degradation that is poorly captured by conventional metrics (Baccini et al., 2017). Recurrent fires, even of low intensity, release 20–30 tCO_2e/ha per cycle (Alencar et al., 2015).

By taking deforestation as the sole indicator of threat, this approach ignores the strategic value of prolonged conservation. It also generates a systematic bias against small and medium-sized properties, in which maintaining forests and agroforestry systems entails recurring costs such as fire prevention, maintenance of fences and firebreaks, and surveillance against illegal extraction. By disregarding these actions as part of climate merit, prevailing models exclude territories that preserve significant carbon stocks.

By financing these properties, in addition to compensating and recognizing the climate benefits already generated, projects make it possible to expand investments in the prevention and management of degradation and to institute periodic monitoring. This reduces the probability and intensity of degradation and increases net removals, with observable and auditable results in time series.

Concurrently, recognizing the additionality of reforestation to the detriment of conservation ignores critical factors from both an ecological standpoint and that of carbon permanence. Reforestation projects, for the most part, present impoverished floristic composition, with a reduced number of species, low genetic and functional variability, and simplified ecological structure when compared to mature forests. Even when successful, such systems do not replicate the biogeochemical attributes, climate resilience, or ecosystem services provided by intact native formations.

This methodological asymmetry persists despite robust evidence that mature forests possess carbon density, structural complexity, and ecological value that cannot be reproduced by reforestation, even after many decades (Poorter et al., 2021). Furthermore, forest restoration projects face significant risks of reversal, especially in the early stages of succession, when they are more exposed to fires, water stress, biological invasions, abandonment, and land-use conflicts. Recent studies show that failure rates and early degradation in such projects are substantial, compromising their climate effectiveness and raising doubts about their real permanence (Strassburg et al., 2020; Crouzeilles et al., 2017).

Even so, such initiatives are often recognized as additional, while the active conservation of native forests—denser, more complex, and more stable—remains systematically excluded from climate finance flows. According to Griscom et al. (2017), the conservation of existing ecosystems represents more than 30% of the cost-effective potential of natural climate solutions by 2030, yet it remains undervalued by prevailing methodologies. Moomaw et al. (2019), in turn, advocate the concept of proforestation—the protection and promotion of the longevity of existing forests—as a central strategy for global climate mitigation, especially in light of the risk of irreversible emissions associated with degradation.

The paradox is evident: the more historically well-conserved the landscape, the lower the likelihood of it being considered additional. Mature forests, stabilized soils, and resilient agroecosystems—precisely the systems most strategic for climate stability—become ineligible for climate finance flows. Instead of being valued as critical mitigation assets, these areas are treated as if their value were already guaranteed and thus are excluded from incentives and compensation mechanisms.

All these methodological impasses—especially the requirement of a disruptive milestone as a condition for recognizing additionality—undermine the viability of projects in the AFOLU sector. In Brazil, where more than 60% of the territory remains under native vegetation cover, whose regulatory, climate, and biodiversity relevance is widely recognized internationally, this bias becomes even more dysfunctional. The very notion of additionality urgently needs to be rethought in light of the ecological, operational, and institutional specificities that define land use in tropical contexts.

4. METHODOLOGY DESCRIPTION

This methodology was conceived as a technical and operational response to the gaps discussed in the previous section, structuring an accounting model capable of coherently and verifiably integrating the multiple environmental and productive components of rural properties. The approach starts from the climate assessment of the farm as a whole, jointly considering the factors that contribute to emissions, removals, and the maintenance of carbon stocks. The project boundary corresponds to the full limit of the property (boundary), with explicit rules for eligibility, exclusions, and data traceability.

The starting point is the construction of a net carbon balance at the property level, which considers:

- **GHG emissions** from agricultural and livestock activities;
- **Carbon removals** by remaining native vegetation, by natural regeneration, or by perennial crops;
- **Carbon stocks** already consolidated, legally eligible, monitored annually, and subject to a measurable risk of reversal.

Since accounting is performed at the whole-farm level—not only on isolated native areas—and is modular with respect to emissions, removals, and stocks, this methodology is applicable to three possible mechanisms:

- **Carbon markets of the offsetting type:** verified carbon units are traded on the voluntary market and used by third parties to offset residual emissions or support climate targets, in accordance with applicable rules.
- **Insetting strategies:** aimed at agribusiness companies seeking to reduce their own emissions and strengthen removals within the value chain by investing directly in the climate performance of supplier properties. In this case, Project Design Documents (PDDs) must demonstrate traceability (chain of custody) and identify, at a minimum, the first recipient—that is, the entity that receives the first delivery of the product/service linked to the result (e.g., a cooperative, a warehouse, or a distribution

center)—with documentation that enables tracing the batch to the final recipient of the insetting claim, consistent with SBTi FLAG principles.

- **Financial instruments backed by environmental assets:** include mechanisms such as the *Cédula de Produto Rural Verde* (CPR Verde), an agribusiness credit instrument that monetizes ecosystem services provided by the rural property—such as conservation of native vegetation, sustainable management, and low-emission practices—enabling the producer to access capital based on the valorization of these assets and reinvest it in actions that strengthen sustainability and productive resilience. All instruments observe safeguards to prevent double counting and registration mechanisms compatible with national systems.

By encompassing these different approaches, the methodology establishes itself as a strategic tool for meeting climate targets, structuring carbon projects in the AFOLU sector, and valuing products and supply chains with lower emissions intensity. Its application is compatible with Greenhouse Gas inventory protocols—including Scope 3—ensuring traceability, regulatory compatibility, and adherence to international sustainability standards. It is compatible with the climate-integrity principles defined by the ICVCM (2023): (i) quantification based on verifiable and replicable data; (ii) feasibility of monitoring over time; (iii) complete traceability of inputs, parameters, and results; and (iv) a conservative and explicit approach to handling uncertainties. The issuance of credits is conditional on independent annual verification (MRV) and on the uncertainty (conservative discounts) and permanence (risk buffer) rules defined in this methodology. The published estimates incorporate a conservative discount for uncertainty and a risk buffer proportional to the project context, with rules detailed in a specific section.

The use of auditable public data and reproducible procedures meets SBTi (2022) requirements for accounting for reductions and removals in the value chain and the principles of the GHG Protocol, with clear mechanisms to prevent double counting. As a result, companies exporting commodities such as coffee, cocoa, citrus, or rubber can demonstrate—based on technical evidence—emissions reductions in the value chain, the absence of deforestation in the production of raw materials, and consistent progress toward science-based climate targets. Whenever applicable, reductions must be demonstrated against baselines updated periodically, with transparency regarding emission factors and remote-sensing methodologies used. Payments for stocks and removals are graduated and conditioned on verified annual performance and on compliance with environmental and social safeguards, ensuring traceability and integrity throughout the cycle.

By transforming these contributions into sound and traceable carbon assets, the methodology enables rural producers—especially small and medium-sized—to be effectively compensated for conserving vegetation, maintaining sustainable systems, and adopting regenerative practices. The producer is thus repositioned as an active agent of the climate transition, with a decisive role in the preservation of biodiversity, environmental regulation, and the resilience of productive landscapes.

Farms as anchors for conservation

A large share of Brazil's most valuable environmental assets is located within private rural properties. Although roughly two-thirds of the national territory—the equivalent of 5.7 million square kilometers, more than the entire European Union—is covered by native vegetation, only a small fraction of this heritage is protected by public conservation units. The vast majority remains under the direct responsibility of rural producers, especially in the Legal Reserves and Permanent Preservation Areas established by the Forest Code (Law No. 12,651/2012).

These areas, distributed across thousands of properties, function as buffer zones, ecological corridors, and carbon sinks essential to environmental resilience—especially in consolidated regions or agricultural frontiers, where remaining native vegetation sustains water stability, soil health, and local climate regulation. In practice, the direct management of a large portion of these environmental assets falls primarily on producers.

However, conservation entails opportunity costs (forgone revenues/uses) and conservation operating costs. Expenses with fencing, fire prevention and firefighting, and monitoring are added to the foregone productive use. Without adequate incentives, maintaining native vegetation implies continuous expenditure, often exceeding the possible return.

The imbalance is structural: producers are legally required to conserve ecosystems that generate global public goods—carbon sequestration, biodiversity, and hydrological regulation—without proportional, recurring financial support. In addition, there are operational enforcement challenges on a continental scale, which maintain a residual risk of conversion even under legal protection. The methodology recognizes this mismatch and establishes objective criteria for eligibility, measurement, and verification so as to convert conservation effort into auditable and monetizable results without replacing legal obligations.

This methodology starts from the recognition that farms are vectors of climate stability. By compensating carbon stocks maintained under risk and continuous effort—without replacing legal obligations—the approach transforms conservation from a recurring cost into a verifiable economic opportunity, repositioning rural properties as strategic agents of Brazil’s and the world’s climate solution.

The value of standing forests and perennial plantations

This methodology repositions conserved vegetation at the center of climate action, recognizing its ongoing role as active carbon reservoirs. It does not treat conservation as the absence of human intervention: maintaining these ecosystems requires active management, operational resilience, and response to recurring risks. In addition to deforestation, it is necessary to address often-underestimated forms of degradation, such as understory fires, selective logging, and gradual expansions within the property. Such management not only mitigates degradation but also preserves a set of essential ecosystem services—water regulation, soil protection, support for biodiversity, and microclimatic stability.

Measuring each of these services in isolation is, however, complex and costly. For this reason, this methodology recognizes carbon stocks and flows as an integrating and operational metric of ecological functionality which, in addition to structuring climate markets, is directly associated with these ecosystem services. Carbon functions as a robust indicator because it correlates with vegetation structure and productivity, soil organic matter and stability, rainfall interception, shading, and functional connectivity. This correlation makes historically under-measured co-benefits (biodiversity, water, soil health) visible and guides evidence-based, integrity-focused decisions.

Within this framework, native ecosystems concentrate large volumes of carbon in biomass and deep soils, maintain complex ecological chains, and favor hydrological regulation—attributes that, captured by the carbon indicator, reliably express the environmental integrity of a landscape.

Complementarily, perennial agricultural systems — such as coffee, cocoa, citrus, and rubber, among others — though they do not replicate the biodiversity of native ecosystems, constitute a long-term climate-aligned alternative for areas currently occupied by short-cycle crops or degraded pastures. Their longevity favors continued carbon sequestration and storage in vegetation and soil; deep root systems stabilize the soil and increase water retention; continuous canopy cover reduces erosion and supports microclimate regulation, increasing below-ground stocks and functional connectivity in productive landscapes.

By recognizing these dynamics, the methodology breaks with the traditional paradigm applied to the AFOLU sector and adopts a logic of climate merit anchored in the maintenance of ecological integrity and in the recognition of the real vulnerability of conserved areas, while valuing perennial productive arrangements capable of reconciling conservation and production.

The urgency of innovation in climate approaches

Brazil is at a turning point. Despite advances in policies and monitoring, deforestation and the degradation of native vegetation continue to pressure environmental targets, weaken rural economies, and reduce ecosystem resilience. Without effective compensation mechanisms for producers who preserve carbon-rich landscapes, land use tends toward degradation trajectories.

This reality requires new approaches. The proposed accounting structure makes it possible to monetize carbon already stored and to guide productive improvements with reliable metrics. Instead of looking only at native areas, the methodology considers the entire farm—croplands, pastures, conserved areas, and areas under regeneration—producing a net balance that is more representative, verifiable, and aligned with Brazil's agricultural diversity. Results are published with reproducible time series, documented targets and uncertainty limits, and independent annual auditing.

Crucially, the methodology does not require 30, 50, or 100-year commitments. Instead, renewable multi-year cycles of five years are adopted, with baseline reassessment and annual verification of stock maintenance. This logic enables proportional and conditional permanence, with payments graduated according to performance. It ensures continuous traceability and a pragmatic response to field risks. Reversal events (e.g., fire, biomass loss) generate immediate proportional adjustments in accordance with permanence and risk-buffer rules.

The MRV system is guided by remote sensing validated by scientific institutions. The prioritization of remote sensing increases transparency, reduces sampling biases, covers fragmented properties, and detects variations within a single vegetation fragment, capturing structural and functional nuances. Algorithms, data sources, and classification/detection parameters will be documented and versioned, allowing replication and auditing.

Finally, the methodology repositions the rural producer as a provider of climate solutions. By directing resources to those who maintain and manage the carbon-richest landscapes, it creates a clear path for environmental recognition and economic valorization based on evidence, technical merit, and climate justice.

Legal framework and national alignment

This methodology is fully aligned with Brazil's environmental policy framework and with the national agenda for climate-change mitigation. It contributes directly to the United Nations Sustainable Development Goals (SDGs) and is supported by the most current and comprehensive legislative instruments, offering a solid legal basis for the recognition, certification, and monetization of climate benefits generated in rural areas. This includes both the conservation and restoration of native vegetation and the comprehensive carbon balance of rural properties.

Legal Basis 1: Law No. 15,042/2024 — Brazilian Greenhouse Gas Emissions Trading System (SBCE).

This federal law establishes the *Sistema Brasileiro de Comércio de Emissões de Gases de Efeito Estufa* (SBCE), which serves as the official regulatory framework for the generation, registration, and commercialization of verified carbon assets in Brazil. It provides legal certainty for carbon projects that promote both emission reductions and carbon stock conservation in rural landscapes.

> **Art. 1º – Instituição do SBCE** "Esta Lei institui o Sistema Brasileiro de Comércio de Emissões de Gases de Efeito Estufa – SBCE..."

"This Law establishes the Brazilian Greenhouse Gas Emissions Trading System (SBCE)…" Establishes the national regulatory platform for verified carbon asset generation and trading.

> **Art. 2º, IV – Definição de Ativos de Carbono** "Ativos de Carbono são os instrumentos representativos da redução ou remoção verificável de gases de efeito estufa da atmosfera. "

"Carbon Assets are instruments representing the verifiable reduction or removal of greenhouse gases from the atmosphere." Recognizes removals from soil carbon and biomass as eligible carbon instruments.

> **Art. 3º – Objetivos do Sistema** "Fomentar investimentos em tecnologias e práticas de baixo carbono; incentivar a conservação de estoques de carbono naturais".

“Promote investments in low-carbon practices; encourage conservation of natural carbon stocks.” Reinforces the methodology’s alignment with forest conservation, agroecological practices, and emission reduction strategies.

Art. 6º – Atividades Elegíveis “São consideradas elegíveis... a remoção de gases de efeito estufa... o aumento de estoques de carbono em biomassa e solos. ”

“Eligible activities include... removal of greenhouse gases... increase in carbon stocks in biomass and soils.” Confirms the legal eligibility of this methodology’s scope and approach.

Art. 9º – Registro Eletrônico “Os ativos... deverão ser registrados... garantindo sua rastreabilidade e transparência. ”

“Carbon assets must be registered… ensuring traceability and transparency.” Ensures traceable issuance of credits via secure, digital registration systems.

Art. 13º – Padrões Metodológicos “As metodologias... deverão atender a padrões internacionais de transparência, precisão, completude...”

“Methodologies must meet international standards of transparency, accuracy, completeness...” Supports the use of conservative carbon accounting, full-farm system boundaries, and robust data integrity.

Art. 17º – Integração com PSA e REDD+ “O SBCE poderá integrar iniciativas de pagamento por serviços ambientais…”

“The SBCE may integrate environmental services payment initiatives…” Confirms the methodology’s compatibility with national PSA initiatives (e.g., Floresta+) and jurisdictional REDD+ frameworks.

Legal Foundation 2: **Law No. 14.119/2021** — *Política Nacional de Pagamento por Serviços Ambientais* (PNPSA). This legislation defines the principles and instruments of the National Policy for Payment for Environmental Services, serving as a policy cornerstone for the valuation and remuneration of ecosystem services, including carbon sequestration and stock enhancement.

Art. 1º – Reconhecimento da Conservação “Esta Lei institui a PNPSA, com o objetivo de reconhecer a conservação dos ecossistemas como atividade de interesse público.”

“This Law establishes the PNPSA, aiming to recognize the conservation of ecosystems as an activity of public interest.” Legally reinforces the core objective of the project—rewarding the protection and stewardship of ecosystem services.

Art. 3º, II – Serviços Ambientais Elegíveis “Sequestro, conservação e melhoria do estoque de carbono”.

“Sequestration, conservation, and improvement of carbon stocks.” Explicitly includes the project's key climate mitigation services as eligible for financial compensation.

Art. 6º – Modalidades de Pagamento “Incentivos diretos por serviços ambientais, inclusive com recursos públicos ou de mercados voluntários”.

“Direct incentives for environmental services, including via public funds or voluntary markets.” Facilitates hybrid revenue streams—through both public PSA programs and voluntary carbon markets.

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5. CONCEPTUAL FRAMEWORKS AND DEFINITIONS FOR GHG ASSESSMENT

This section provides the conceptual elements necessary to interpret and apply the carbon accounting approach of this methodology. It includes clear definitions of the main terms used throughout the document, a standardized list of acronyms covering technical terminology, as well as a conceptual overview of GHG metrics, conversion factors, and the methodological levels applied to the quantification and reporting of emissions.

5.1. Definitions

Additionality: The condition by which climate benefits—such as the maintenance or increase of carbon stocks—are recognized as eligible for credit generation because they result from defined actions that go beyond usual land-use practices. In this methodology, additionality includes both the prevention of deforestation and degradation, as well as the active removal of carbon, demonstrated through comparisons with reference regions in spatial-temporal, climatic, and socioeconomic terms and anchored in national legal frameworks.

CPR Verde: a credit note backed by the Rural Product Note (*Cédula de Produto Rural*, CPR) instituted by Law No. 8,929/1994 and regulated—for activities involving the conservation and restoration of native forests and their biomes—by Decree No. 10,828/2021. It is linked to environmental assets or services generated on the rural property (e.g., conservation and restoration of native vegetation, sustainable management, emission reductions and increased carbon removals) and operates as a financial instrument that allows the rural producer to obtain advance funds from investors or financial institutions, subject to a contractual commitment to deliver or maintain the agreed environmental conditions.

Carbon Credit: A unit representing the removal or non-emission of one (1) metric ton of CO_2 equivalent (tCO_2e), verified and issued under the rules of a certification program.

Carbon Stock: The amount of carbon contained in a reservoir at a given moment, expressed in tons of carbon or CO_2 equivalent.

Emission Factor: A coefficient that quantifies emissions or removals per unit of activity, based on IPCC or regional data.

Standing Forests: Native vegetation that has not undergone recent disturbances and continues to provide climate, ecological, and cultural services. Recognized by this methodology as an active carbon sink and as a strategic asset of permanence and climate integrity.

IBGE (Brazilian Institute of Geography and Statistics): Federal agency responsible for producing, analyzing, and disseminating geographic, statistical, demographic, and socioeconomic data in Brazil. Its cartographic databases and territorial information—such as municipal grids, administrative boundaries, urban classifications, and census zones—are widely used as an official reference in spatial studies, public planning, and validation of data in environmental and land-use projects.

Insetting: Reduction or removal of GHGs within a company's own value chain, commonly used for mitigation of Scope 3 emissions and sustainability commitments. Requires full traceability to at least the first recipient in the chain, in accordance with SBTi FLAG.

GHG Boundaries: The set of all GHG sources and sinks within the spatial, operational, and temporal boundaries of the project. They must be explicitly documented to ensure completeness and consistency with the GHG Protocol.

Baseline: Represents a scenario of land use, GHG emissions, and carbon stocks in the context of the farm and its reference region. It is based on data observed in the five years prior to initiation, including trends of the property and of the reference region. It serves as a basis to demonstrate net carbon benefits and must be updated every five years.

MapBiomas: A Brazilian multi-institutional initiative that produces annual historical series of land-use and land-cover maps from satellite imagery, based on a standardized, transparent, and open-source methodology. MapBiomas data are widely used for environmental monitoring in Brazil, public policy development, and sustainability analyses, offering nationwide coverage with high temporal resolution (since 1985) and spatial resolution (30 meters), with thematic classification validated by specialists.

Offsetting: The use of verified emissions reductions or removals from external projects to offset the emissions of a given entity. Offsetting must comply with the principles of additionality, permanence, and the absence of double counting.

Credit Period: The period during which verified climate benefits are eligible for issuance as carbon credits. This methodology adopts renewable crediting cycles of five years, which may be extended provided that project conditions are maintained or improved and all parties involved remain in agreement.

Permanence: The expected duration of carbon storage, considering the risk of reversal. In this methodology, permanence is not fixed by a speculative and arbitrary horizon (e.g., “100 years”). It is achieved through annual verification and multi-year audits, with baseline reassessments and renewable project cycles, anchoring credits in recent observations and allowing conservative corrections. In Brazil, the Forest Code regime—Legal Reserve (RL) and Permanent Preservation Areas (APP)—imposes continuous safeguards over a large part of properties, which, combined with monitoring, increases the effective durability of stocks without resorting to speculative projections. Reversal events are addressed through buffer mechanisms and proportional deductions.

Project Design Document – PDD: Central reference document for each project, describing its boundaries, baseline, additionality criteria, methods for quantifying carbon stocks, removals and emissions, monitoring plan, and risk management mechanisms. Within the scope of this methodology, the PDD must include all inputs, models, emission factors, data versions, and scripts used, ensuring full traceability, third-party verification (VVB), and alignment with national and international MRV standards. For *insetting* projects, the PDD must also demonstrate chain-of-custody traceability by identifying at least the first recipient of the associated products, thereby ensuring transparency in the application of credits within the project’s own value chain.

Reference Region: A defined jurisdictional area used to analyze regional land-use trends, deforestation pressures, and climate vulnerabilities. It supports the assessment of additionality and permanence. Its definition must be justified and documented, ensuring comparability and transparency.

Carbon Reservoir: A system that stores carbon, such as above-ground and below-ground biomass, deadwood, litter, and soil organic carbon. The methodology includes only some of these compartments.

Ecosystem Services: Benefits provided by ecosystems, such as climate regulation, water purification, erosion control, biodiversity, and cultural values.

Carbon Sink: A process or mechanism that removes GHGs from the atmosphere and stores them in reservoirs such as biomass or soil.

Project Verification: An independent assessment carried out by a third party that confirms the conformity of project activities and carbon accounting with the methodology and certification program requirements. It includes auditing of information (whether primary data, secondary data, or derived analyses), traceability, and the application of statistical sampling in accordance with international auditing standards.

5.2. Acronyms

AFOLU: Agriculture, Forestry and Other Land Uses.

AGB: Above-Ground Biomass.

APP (*Área de Preservação Permanente*): Permanent Preservation Area.

BGB: Below-Ground Biomass.

CAR (*Cadastro Ambiental Rural*): Rural Environmental Registry.

CO_2: Carbon Dioxide.

CO_2eq: Carbon Dioxide Equivalent.

CPR Verde (*Cédula de Produto Rural Verde*): Green Rural Product Note (financial instrument linked to environmental services).

DETER (*Detecção de Desmatamento em Tempo Real*): Real-Time Deforestation Detection System.

ESRI: Environmental Systems Research Institute (international institute specialized in geographic information systems – GIS).

FLAG: Forest, Land and Agriculture sector under SBTi.

GHG: Greenhouse Gas

GHG Protocol: Greenhouse Gas Protocol (International Standard for Emissions accounting).

GWP: Global Warming Potential.

IBGE (*Instituto Brasileiro de Geografia e Estatística*): Brazilian Institute of Geography and Statistics.

ICVCM: Integrity Council for the Voluntary Carbon Market.

IPCC: Intergovernmental Panel on Climate Change.

MRV: Monitoring, Reporting and Verification.

MTE (*Ministério do Trabalho e Emprego*): Ministry of Labor and Employment.

N_2O: Nitrous Oxide.

PDD: Project Document Design

PES: Payment for Environmental Services.

PNPSA (*Política Nacional de Pagamento por Serviços Ambientais*): National Policy for Payment for Environmental Services.

PRODES (*Projeto de Monitoramento do Desmatamento na Amazônia Legal por Satélite*): Project for Monitoring Deforestation in the Brazilian Amazon by Satellite.

REDD+: Reducing Emissions from Deforestation and Forest Degradation.

RL (*Reserva Legal*): Legal Reserve.

R:S: Root-to-Shoot Ratio (relationship between above-ground and below-ground biomass).

SBCE (*Sistema Brasileiro de Comércio de Emissões de GEE*): Brazilian Greenhouse Gas Emissions Trading System.

SBTi: Science Based Targets initiative.

SOC: Soil Organic Carbon.

UNFCCC: United Nations Framework Convention on Climate Change.

VVB: Validation and Verification Body.

5.3. GHG Metrics and Conversions

5.3.1. Global Warming Potential (GWP)

Emissions are reported for the main greenhouse gases (GHGs) associated with agricultural activities: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). These gases are recognized as the primary contributors to on-farm emissions resulting from agricultural production. To standardize reporting, the emissions of each gas are converted into metric tons of carbon dioxide equivalent (tCO_2e), using the 100-year time horizon Global Warming Potential (GWP) values provided by the Working Group I of the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6), Supplementary Material, Chapter 7 (Table 7.SM.7):

- Carbon dioxide (CO_2): GWP = 1
- Methane (CH_4): GWP = 27.9

- Nitrous oxide (N_2O): GWP = 273

By applying these GWP values, emissions of different gases are expressed in a unified metric, allowing consistent comparison and aggregation of GHG contributions. This methodology adopts AR6 as the default standard, and may be updated if future official revisions of the IPCC are published.

5.3.2. Emission Conversion for GHG Reporting

Emissions originally reported in terms of elemental carbon (C) or nitrogen (N) are converted to their corresponding gaseous forms using the following molecular weight ratios:

- 1 tonne CH_4-C = $\left(\frac{16}{12}\right)$ × 1 tonne CH_4 = 1.33 tonnes CH_4;
- 1 tonne N_2O -N = $\left(\frac{44}{28}\right)$ × 1 tonne N_2O = 1.57 tonnes N_2O;
- 1 tonne C = $\left(\frac{44}{12}\right)$ × 1 tonne CO_2 = 3.67 tonnes CO_2;

6. APPLICABILITY CONDITIONS

This methodology applies to rural properties that wish to claim climate credits resulting from the continuous conservation of native vegetation, forest restoration, active ecosystem management, and the implementation of long-term agricultural practices with a positive carbon balance. It is also compatible with jurisdictional or voluntary initiatives that include Payments for Environmental Services (PES) or REDD+ under broader frameworks that recognize existing stocks and the overall climate performance of the landscape.

- The project must not result in the violation of any applicable environmental, labor, or land laws, including those already approved and with established validity during the project period.
- Projects may be implemented by any stakeholder with legal access or management rights, including landowners, cooperatives, communities, NGOs, private companies, or national and local governments.
- The project area must not be subject to any other AFOLU carbon project, whether registered, under development, or planned, during the implementation period or the crediting period of the current project, nor generate credits simultaneously in more than one program or registry, except when explicitly permitted by international rules (e.g., Article 6 of the Paris Agreement).
- Project areas that overlap, in whole or in part, with mining titles or concessions recorded with the National Mining Agency (ANM) — including applications/authorizations for exploration, mining concessions, trial mining permits (*Guia de Utilização*), and the related easements/right-of-way for associated infrastructure—are ineligible for the accounting of carbon stocks, GHG emissions reductions/removals, and the issuance of credits for as long as such titles remain in force; eligibility may be reinstated only upon documentary evidence of the extinction/cancellation of the title and the absence of any mining restrictions currently in effect over the area.
- The project proponent must have clear and verifiable authorization to operate within the designated area. The project must also be duly regulated and must not overlap with Conservation Units or officially recognized territories of Indigenous or Quilombola communities.

- Fragments of native vegetation will only be eligible if duly registered in the Rural Environmental Registry (CAR), identified as Permanent Preservation Area (APP), Legal Reserve, or polygons recognized as remnant Native Vegetation.
- For areas of native vegetation, only fragments that have not been cleared after July 22, 2008, as established in Article 68 of Law No. 12.651/2012 (Forest Code), are eligible for the accounting of carbon stocks. Fragments deforested after this date may be included in restoration activities (provided the clearing did not occur within the last 10 years prior to the project start), but are excluded from the generation of credits related to historical carbon stock. However, the existence of these areas does not invalidate the eligibility of the farm as a whole, nor compromise other fully compliant native fragments.
- Landowners must ensure fair working conditions, including formal employment contracts, adequate remuneration, and full respect for human rights; evidenced by labor clearance certificates and an assessment of social liabilities. This includes demonstrating the absence of outstanding labor liabilities, consulting the Register of Employers that have subjected workers to conditions analogous to slavery ("Dirty List") of the Ministry of Labor and Employment (MTE), and respecting the rights of Indigenous peoples, Quilombola communities, and traditional communities, in accordance with applicable national and international standards.
- Projects are eligible regardless of the presence of perennial crops — for example, properties with only native vegetation, annual crops, or livestock activities are also eligible.
- The project boundary may include one or several implementation areas, contiguous or not, provided that all the above conditions are met.

To reinforce credibility and transparency, supporting documentation proving compliance with these requirements must be compiled and included in a specific annex, accessible only to the certification body due to the confidential nature of the information. Although these documents are not publicly disclosed, they serve as solid evidence of compliance with legal, environmental, and social requirements, further strengthening the project's credibility and its acceptance in the carbon market (see Table 1).

Table 1. Technical Guidelines for Eligibility Verification – Project Documentation and Location

Project Documentation	
Project Owner Documentation	Provide identification documents of the legal representative responsible for the project area.
***Cadastro Ambiental Rural* (CAR)**	Provide proof of registration of the project area in the Rural Environmental Registry (CAR) system, accompanied by the respective georeferenced vector file of the property (shapefile format).
Title of Ownership, Possession, or Lease Agreement	A valid and updated document must be submitted to prove ownership, possession, or paid assignment of the project area, such as property registration certificate, transcript of the land registry, valid lease agreement, public deed, deed of transfer of use, or other legally valid document.
Environmental Compliance of the Property	Provide a statement and supporting documentation of compliance with the competent environmental authorities (municipal, state, and federal), including verification of embargoes, notices of violation, environmental liabilities, and other restrictions that may affect eligibility. Where outstanding issues exist, cases under a regularization process may be accepted provided that the process is formally initiated (e.g., active filing number, registration in the CAR, a signed *Termo de Ajustamento de Conduta* (TAC) — a legally binding conduct-adjustment agreement under Brazilian law —, *Plano de Recuperação de Área Degradada* (PRAD)/licensing in progress), or equivalent instruments/documentation in the relevant jurisdiction, with up-to-date evidence maintained.
Labor Certificates and Assessment of Social Liabilities	Conduct a search and attach up-to-date evidence of no outstanding issues, including: (i) verification of the Register of Employers that have subjected workers to conditions analogous to slavery ("Dirty List") of the Ministry of Labor and Employment (MTE); and (ii) the Electronic Certificate of Labor Actions (CEAT) issued by the Labor Courts.
Project Location	
Overlap with Protected Areas	Conduct spatial analysis to identify overlaps between the project area and legally protected zones or restricted-use areas. The following must be verified: (i) Embargoed Areas (IBAMA and state agencies); (ii) Indigenous Territories; (iii) Quilombola Territories; (iv) Conservation Units (UCs); and (v) records of Environmental Infractions. The analysis must be based on official and up-to-date data.
Overlap with Mining Concessions	Conduct spatial analysis using the official SIGMINE database, maintained by the National Mining Agency (*Agência Nacional de Mineração*, ANM) — a federal regulatory agency responsible for regulating, supervising, and managing mineral rights in Brazil. Use the vector files published on the SIGMINE Open Data Portal (titles/authorizations for application, exploration, mining, etc.), recording the date of access and the dataset version.

Deforestation and Land Use History	Assess the occurrence of deforestation in native vegetation areas based on the legal cut-off date of July 22, 2008, in accordance with the Forest Code (Law No. 12.651/2012). To substantiate eligibility and establish the baselines of emissions, removals, and stocks, it is necessary to carry out land use and land cover mapping in the project area. The assessment must be based on technical and scientific evidence, such as satellite image time series, official cartographic records, public geospatial data, and documents that prove the history of land use and land cover in the analyzed period.

7. PROJECT BOUNDARIES

This section defines the project's spatial, temporal, and carbon-accounting boundaries. Clear definition of these boundaries is essential to ensure consistency in land eligibility, baseline setting, GHG quantification, and the attribution of mitigation results to project activities.

7.1. Spatial Boundaries

7.1.1. Project Area

The project area covers the full spatial extent of each participating property, as defined by georeferenced polygons submitted via the Rural Environmental Registry (Cadastro Ambiental Rural – CAR). A whole-farm approach is adopted to ensure that all land uses, potential emission sources, and carbon sinks are fully accounted for in the project's carbon balance. The coordinate reference system (CRS) adopted must be specified, and any transformations or reprojections performed must be recorded and documented.

Before classifying land use/land cover within the project area, the following land-use categories must be identified, isolated, and excluded from the calculation of native and agricultural areas:

- Built infrastructure (e.g., paved roads, residences, sheds, corrals)
- Permanent water bodies (e.g., lakes, rivers, reservoirs)
- Public easement areas (e.g., zones legally designated for administrative easements)

These excluded areas must be clearly separated from native and agricultural areas in the spatial datasets, even if they were originally included in the CAR polygons submitted for the project. Identification and separation of these areas may be performed using the most recent, high-resolution land-use/land-cover raster data available at the time of project submission (such as the MapBiomas Project, PRODES/DETER, base maps from the Environmental Systems Research Institute – ESRI, or equivalent recognized sources) and spatial information from CAR shapefiles or equivalent property maps. Where sources diverge, a documented data hierarchy (prioritizing official/validated sources) must be applied and the decisions recorded. Reclassifications using machine-learning techniques (for example, with Sentinel imagery) may be used, provided the entire process, parameters, and final products are fully documented and versioned.

The remaining eligible project area must then be classified into two main land-use categories:

7.1.1.1. Native vegetation areas

All natural ecosystems—including forests, savannas, wetlands, and other native vegetation formations—must be mapped and classified into homogeneous categories based on their structural and functional characteristics. For carbon accounting purposes, each native vegetation type must meet the following criteria:

- **Ecological Stratification:** Vegetation formations must be stratified according to their ecological classification (e.g., forests, savannas, wetlands), using official and recognized maps such as the Vegetation Maps of the Brazilian Institute of Geography and Statistics (IBGE), MapBiomas Native Vegetation Layers, or other equivalent technical-scientific sources;
- **Distinct Spatial Representation:** Each vegetation class must be represented as an individualized polygon within the project's geospatial dataset, allowing unique identification of its characteristics and separate accounting in greenhouse gas (GHG) estimates;
- **Separate GHG Quantification:** Different formations must be assessed separately when quantifying removals and carbon stocks, respecting their ecological specificities;
- **Proof of Legal Eligibility:** Areas must be supported by technical-scientific and cartographic evidence demonstrating the absence of native vegetation clearing after July 22, 2008, as defined by the Forest Code (Law No. 12,651/2012). Only areas meeting this criterion are eligible for carbon stock accounting. For the eligibility of

removals from native vegetation, clearing must not have occurred within the 10 years prior to the project start.

7.1.1.2. Agricultural Areas

Agricultural areas included in the project must be mapped and georeferenced, forming management units that are coherent in terms of land use, crop type, and predominant practices. These units will be used to estimate GHG emissions and carbon removals.

Classification of agricultural areas:

Agricultural areas must be classified into the following categories:

- **Annual crops:** defined by the presence of short-cycle crops (e.g., soybean, corn, beans, cotton, among others), and must be identified by specific crop type;
- **Perennial crops:** defined by long-lived species (e.g., coffee, citrus, cocoa, and rubber, among others), and must be classified by species and planting age, since biomass and carbon dynamics vary by stage. Plantings under renovation must be indicated separately;
- **Pastures:** areas for livestock grazing in extensive or intensive systems. Predominant management practices must be described, such as extensive, rotational, pasture renovation, or fertilization.

Recommended information for each management unit:

- Spatial geometry of the area (shapefile);
- Predominant use type (crop or pasture);
- General management practices (soil tillage, fertilization, irrigation, ground cover);
- Land-use history (where applicable: irrigation; type/rate of nitrogen fertilizer; pruning and biomass disposition; post-harvest/processing—e.g., drying/cleaning/energy use; burning practices).

Seasonal changes (such as crop rotation) do not invalidate the management unit, provided the overall consistency of use and management is maintained. In such cases, a justification must be presented.

7.1.2. Reference Region

The Reference Region provides the broader spatial and jurisdictional context for assessing land-use dynamics, environmental pressures, and climate risks relevant to the project. Its role is to support, on an empirical and territorial basis, the additionality criteria and the baseline delineation.

In this methodology, each Reference Region must reflect the ecological and administrative context of the project area, noting that:

- Projects with a single contiguous area or with multiple areas that are relatively close (e.g., located within the same mesoregion or a cohesive administrative unit) may adopt a single Reference Region, provided it encompasses all project areas in a representative manner.
- Projects with multiple, dispersed areas—especially when located in different states, biomes, or contexts—must define separate Reference Regions, one for each coherent cluster.

Each Reference Region must:

- Be a spatially continuous unit or an area coherent from the jurisdictional, ecological, or land-tenure standpoint;
- Fall within the same biome, agroclimatic zone, or administrative region as the corresponding farm(s);
- Be at least 50 times the total area of the property(ies) it represents;

A descriptive characterization of climate, soil, vegetation, and land-use dynamics must be prepared for each Reference Region. This description supports the selection of emission factors (e.g., distinction between humid and dry climates) and provides the environmental context needed to interpret vegetation distribution, carbon stock levels, temporal dynamics, and comparative sequestration or emission rates. It also strengthens transparency and credibility in modeling assumptions, baseline projections, and scenario comparisons.

The climate characterization must include, at a minimum: mean annual precipitation, mean annual temperature, and records of extreme climate events (e.g., droughts, floods, and heat waves). Strongly recommended are the inclusion of interannual variability, seasonal climate, and/or zonal climate classification (e.g., Köppen types). In accordance with the 2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories, the climate must also be classified as humid or dry—an essential distinction for emission-factor selection. In tropical zones, a humid climate is considered one with annual precipitation above 1,000 mm, and a dry climate one with annual precipitation below 1,000 mm (see Figure 3A.5.1, Chapter 3, Volume 4 of the IPCC Guidelines). Other classifications may be used, provided they are supported by documentary evidence and technical justification.

For soil characterization—which may be based on the most recent and reliable data available, given its relative temporal stability—the following variables must be included, at a minimum: dominant soil classes, texture (percentage of sand, silt, and clay), and pH.

The ecological and land-use description must identify the predominant vegetation types and ecological attributes relevant to the Reference Region, including the biome in which the project is located, the dominant vegetation formations, and the history of land-use conversion. It is recommended to analyze indicators such as: (i) the current share of remaining native vegetation relative to the biome's current cover; (ii) the percentage of areas protected as conservation units; (iii) annual deforestation rates; (iv) fire history. The years analyzed, the collections/versions used, the data sources, and access URLs (links) must be specified to enable reproducibility.

These indicators provide an empirical basis for assessing environmental vulnerabilities and help build project additionality. For example, regions with vegetation cover significantly below the biome average, with high recent anthropic pressure, or with recurrent extreme events may objectively justify future conversion risk and, therefore, the eligibility of conservation actions as additional activities.

All data on climate, soil, vegetation, and land use may be obtained from recognized public sources such as SoilGrids 2.0, the Brazilian Soil Map, MapBiomas, PRODES, BDQueimadas, IBGE, or equivalent sources validated by scientific or governmental institutions. Whenever a private source is used (for example, a commercial provider), its methodology and validation must be described in a technical annex.

7.2. Temporal Boundaries

The project start date corresponds to the initial milestone of eligible land-management activities aimed at mitigating greenhouse gases (GHG).

- **For restoration, reforestation, or active management projects:** the start date is when the first material interventions in the area began (e.g., soil preparation, planting, fencing, control of invasive species).

- **For conservation-only projects**: the start date is the monitoring milestone defined in the Project Design Document (PDD), from which the maintenance of stocks in the project areas is evidenced via remote sensing. Minimum evidence: (i) a series of dated images (e.g., Landsat/Sentinel) supporting the reported condition; and (ii) a statement by the proponent attesting to the start and continuity of conservation.

To validate conservation-only projects and avoid retroactive crediting, the start milestone may not precede by more than 24 months the first formalization with a Validation and Verification Body (VVB) (e.g., submission of the PDD). Exceptions may be accepted only with robust technical justification and documentary evidence demonstrating the continuity and integrity of management actions from the claimed start date, without significant temporal interruptions. Approved exceptions must be explicitly reported in the PDD.

The crediting period is established in five-year cycles and may be renewed as long as project conditions are maintained or improved and all parties remain in agreement. Carbon credits are issued based on verified performance within each cycle and are subject to third-party verification by an accredited VVB.

Monitoring shall occur annually and cover:

- Changes in carbon stocks and removals (sequestration) — in native vegetation and perennial systems, with identification of reversals where applicable;
- Emission sources associated with agricultural and land-use activities;
- Land-use and land-cover changes (conversion, degradation, recovery), including planned changes, with schedule/timeline, designated area, and planned practices to be adopted.

Detailed requirements for the monitoring report are provided in **Section 15 “Monitoring Plan”**. Monitoring reports must be submitted to the VVB and verified within the reporting deadlines established in the project schedule. At the end of each five-year crediting cycle, a new baseline reassessment must be carried out.

Updated baselines must reflect methodological advances, improvements in data availability and resolution (e.g., satellite imagery, enhanced datasets), and revisions to emission factors or modeling parameters. Whenever new scientifically validated information becomes available, emission factors, carbon stocks, and other coefficients must be updated. All data or model changes must be versioned and documented (cut-off date, version, source, and parameters).

Critically, updated baselines must maintain or improve the carbon stock levels established in the previous cycle. Reductions in baseline levels (i.e., decreases in projected stocks) are not allowed, except in cases of duly justified force majeure (e.g., extreme droughts, pest outbreaks, externally caused fires) and independently validated by the VVB.

Each baseline must be built on representative time series of land use/land cover, vegetation dynamics, and risk indicators (e.g., deforestation, degradation, fires) observed in the Reference Region during the five years prior to the start date of the respective cycle. This temporal linkage with the Reference Region ensures that the baseline reflects real and up-to-date conditions of the project's ecological and socioeconomic context, reinforcing the credibility of projections and the consistency of additionality criteria.

7.3. Carbon assessment: Sources, Sinks, and Pools

The carbon accounting boundary covers all existing and measurable greenhouse-gas (GHG) sources, sinks, and pools within the physical area of the participating property (farm-gate boundary), including exclusively the activities under the proponent's direct control.

Scope 1 emissions (direct GHG emissions from owned or controlled sources) and Scope 2 emissions (indirect GHG emissions from purchased electricity) resulting from activities carried out within the property are accounted for. Scope 3 emissions (indirect emissions not included in Scope 2, such as emissions embedded in purchased inputs or external transport) are excluded from this methodology. This methodology is exclusively focused on the farm boundary and does not replace corporate inventories of buyers (which cover waste, industrial processes, etc.).

When verified project results are used by purchasing companies, any attribution must occur in the purchaser's corporate inventory as Scope 3—for example, Category 1 (Purchased Goods and Services)—provided there is documentary traceability (chain of custody) identifying, at a minimum, the first recipient—that is, the entity that receives the first delivery of the product/service linked to the result (e.g., a cooperative, warehouse, or distribution center)—with documentation that allows tracing the batch to the final recipient of the claim, and with allocation rules described in the PDD. Under these conditions, reductions associated with lower land-use change and/or lower degradation in areas of native vegetation and verified biogenic removals (native vegetation and perennial crops) may be reported as Scope 3 (Category 1) emission reductions by the purchaser, in accordance with the GHG Protocol Land Sector & Removals Guidance, provided allocation and traceability requirements are met and double counting is avoided. Use of these results for SBTi targets must follow FLAG and/or supplier-engagement criteria; they do not constitute offsets for

Scopes 1 and 2, are not intended to compensate those scopes, do not alter them, and do not replace the company's own reductions required by the SBTi.

Only GHG flows arising from activities carried out within the project area are included. Emissions from external processes, even if associated with products or by-products of the property, are not accounted for. Examples:

- Combustion of wood produced within the property boundaries but burned at an external plant is not accounted for in the project inventory;
- Emissions associated with the transport of purchased inputs or the manufacture of fertilizers are considered Scope 3 and therefore excluded.

The temporal accounting horizon follows the guidance set out in **Section 8 "Baseline Scenario and Reference Period"**, consistent with the nature of each flow or pool. All accounting must comply with the IPCC Good Practice Guidance for the LULUCF and AFOLU sectors, applying Tier 1 to Tier 3 methodologies as a function of project data availability and quality.

7.3.1. Data Traceability Requirements

All geospatial datasets, emission factors, coefficients, and parameters used must record at least the following information, to be retained for audit and reproducibility purposes:

- Original dataset or emission-factor name and version;
- Source (responsible organization, URL, or bibliographic reference);
- Cut-off date (reference period or extraction date);
- Pre-processing applied (for example: projection change, spatial clipping, land-use class reclassification, interpolation, quality filters). Scripts, models, and intermediate layers must be archived and made available to the VVB under confidentiality.

7.3.2. GHG Sources and Pools

The emission sources and carbon pools relevant to this methodology are listed in Tables 2 and 3, which set out the greenhouse gases involved, inclusion criteria, and specific observations for each case. Although the methodology includes a comprehensive set of emission sources and carbon pools, only those associated with land uses or activities actually conducted within the project area will be accounted for.

Table 2 – GHG Emission Sources included within the accounting boundary.

Emission Source	GHG	Inclusion Criterion / Technical Note
Use of fossil fuels	CO_2	Combustion of diesel, gasoline, or other fossil fuels in tractors, harvesters, irrigation pumps, and transport vehicles operated within the property.
Use of electricity	CO_2	Electricity consumption measured at the property's grid connection point(s). Includes energy for irrigation, processing, or climate control.
Application of nitrogen fertilizers	N_2O, CO_2	Direct and indirect emissions (via volatilization and leaching) associated with the application of nitrogen fertilizers. Urea-based fertilizers must additionally include CO_2 emissions from their decomposition. Only input applications carried out within the property boundary are considered.
Liming	CO_2	CO_2 emissions resulting from the reaction of lime (calcitic or dolomitic) with the soil.
Management of crop residues	N_2O	N_2O emissions from nitrogen decomposition in post-harvest residues of annual crops and maintenance residues of perennial crops (e.g., pruning, fruit processing).
Biomass burning (natural causes or energy use)	N_2O, CH_4, CO_2	N_2O and CH_4 emissions from biomass burning in agro-industrial structures installed within the property, such as boilers, dryers, or furnaces. CO_2 emissions resulting from fires affecting native vegetation within the property, regardless of cause (natural or anthropic). Emissions associated with burning native vegetation are addressed in detail in the carbon-stock estimation section, given their direct relationship with biomass and vegetation-loss dynamics. Burning in external facilities is excluded from this methodology.
Livestock	N_2O, CH_4	CH_4 emissions from enteric fermentation and manure management, and N_2O emissions from manure management, where animals are raised on the property, by species and different categories as specified in this methodology.

Measurement and auditing of GHG emissions and removals under this methodology should preferably be based on primary data obtained directly from farm operations or, where necessary, on duly justified secondary data consistent with the project area's production and technological profile. The main procedures are as follows:

- **Fossil fuels:** Consumption must be recorded using primary data (e.g., purchase invoices, operating logs, direct fueling measurements) or secondary estimates consistent with activities actually conducted. These estimates may be based on machine-hours and average rates by equipment type, adjusted to the property's operational profile and obtained from technical sources or recognized national inventories.

- **Electricity:** Emissions must be estimated from meter readings or utility bills, multiplied by national grid emission factors (e.g., those published by Brazil's Ministry of Science, Technology and Innovation (MCTI) via SIRENE — Brazil's GHG Emissions and Removals Estimates System — or equivalent). These estimates may rely on recognized technical sources or national inventories and be adjusted to the property's operational profile.
- **Nitrogen fertilizers:** The quantity applied (in kg of N) and the type of fertilizer used per crop must be recorded. Measurement may use primary data, such as invoices, agronomic records, and technical prescriptions, or, where unavailable, secondary data consistent with the production system. In this case, estimates based on productivity and regional average doses are allowed, provided they are obtained from technical sources or official inventories and justified to the Validation and Verification Body (VVB).
- **Liming:** Recording the quantity and type of soil amendment applied (e.g., calcitic, dolomitic) must be based on primary data (invoices, agronomic reports, application records). Justified secondary estimates are also accepted, based on soil requirements, property historical practices, and regional technical recommendations.
- **Biomass burning in agro-industrial structures**: Emissions must be measured based on operational records of biomass consumption (e.g., firewood in boilers, volumes processed by dryers or furnaces). Primary data such as operating logs, energy-consumption reports, and invoices for purchased biomass may be used. When necessary, secondary estimates are allowed, consistent with the installed capacity of the structure and the activities conducted.
- **Fires:** The occurrence of fires must be substantiated by documentary evidence identifying their date, location, and affected area. Medium- or high-resolution satellite imagery (before/after the burn), official records such as DETER alerts and active-fire data from platforms such as BDQueimadas/INPE may be used. Affected areas must be spatially cross-referenced with estimated biomass stocks, as described in the native vegetation section, to quantify associated CO_2 emissions. Cross-checking dates, intensity, and recurrence is recommended to adequately estimate impacts on carbon stocks.
- **Livestock:** Animal inventory must be carried out by category (e.g., cattle, swine, poultry), based on primary data such as tax invoices for purchases and sales, Animal Transit Guides (Guia de Trânsito Animal, GTA), registrations with competent

authorities, mandatory vaccination records, recognized traceability systems, or rural credit documentation. These records must reflect the composition and size of the livestock population for the reference period.

Table 3 – Carbon pools to be assessed and monitored.

Carbon Pool	Included	Inclusion Criterion / Technical Note
Above-ground woody biomass	Yes	Mandatory in all native vegetation areas and in eligible agricultural areas with perennial crops. Estimated by remote sensing (biomass layers) and/or documented in-house spatial models. In perennial crops, existing stocks are monitored for consistency; only net increment (removals) is credit-eligible. Non-woody biomass is excluded.
Below-ground biomass	Yes	Estimated from recognized root-to-shoot (R:S) ratios (IPCC 2006/2019; peer-reviewed sources). Prioritize values by physiognomy/biome; for perennials, use species-specific ratios where available. In the absence of local values, apply conservative ratios and justify the choice.
Litter and dead wood	No	Excluded to simplify modeling and reinforce conservativeness. Losses or gains associated with disturbances appear indirectly through changes in woody biomass and are handled under the reversal/adjustment rules.
Soil organic carbon (SOC)	Optional	By default, this methodology does not credit SOC. Projects opting to include SOC must adopt a verifiable, compatible methodology; present a sampling and uncertainty plan; maintain a separate module (with no cross-compensation with AGB/BGB); and obtain prior consent from the VVB.

Measurement and auditing of pools:

- **Above-ground woody biomass (AGB):** preferably use recognized public layers and/or trained and validated spatial models. Harmonize resolution, projection, and dates; record dataset version and cut-off date. Use robust statistics for outlier control.
- **Below-ground biomass (BGB):** derive using an R:S ratio consistent with vegetation type and climate; cite the source and justify any regional adjustments.
- **Uncertainty:** where the chosen raster provides an error band/metadata, use it directly; where not available, estimate RMSE via cross-validation of the spatial model or independent comparison on samples within the Reference Region (for example, GEDI footprints or alternative maps). Apply the uncertainty deductions defined in the methodology before final accounting.

- **Traceability**: for each input, record name, version, source, spatial/temporal resolution, acquisition date, and pre-processing; keep all scripts and intermediate layers archived for VVB audit. Differences between successive versions must be documented with a technical impact note.

8. BASELINE SCENARIO AND REFERENCE PERIOD

The baseline provides the context necessary to assess the carbon benefits generated by the project. It describes the conditions prior to the start date, both within the property and in the reference region, and serves to:

- Recognize and quantify the carbon results associated with existing and newly implemented good practices;
- Calculate baseline GHG emissions, carbon stocks, and potential removals;
- Support additionality and permanence assessments through trends observed in the reference region.

The baseline must be constructed with the data, methods, and assumptions available at the time of its definition, with full documentation of sources, versions, and methodological choices, and with a conservative approach.

As a general rule, the baseline reference period covers the five years immediately prior to the project start date. This interval may be adjusted according to the nature of each analysis, GHG sources, or carbon reservoirs. For example, to assess regional climate vulnerabilities, a longer period may be necessary; for emissions from operational activities, more recent records (such as fertilizer consumption or herd size in the year prior to the start) tend to be more representative. When there are adjustments to the period (either longer or shorter), the technical rationale and the expected impact on uncertainty must be set out in the PDD.

Using historical series prior to the start date makes it possible to capture interannual variability in management practices, climatic conditions, and biomass accumulation, in addition to confirming stability or identifying changes in land use within the project area. This historical context strengthens the assessment of carbon performance. New baseline periods must be defined every five years during the project’s term. All updates must maintain reproducibility (scripts and versions archived) and methodological consistency throughout the time series.

The baseline comprises two analytical levels:

- **Farm-Level Baseline:** Understanding land use, management practices, carbon stocks, and GHG emissions on the participating farms.
- **Reference Region Baseline:** Analysis of broader trends in land use, vegetation loss, and risks to permanence within the defined reference region.

Both components are necessary to establish the initial carbon balance, assess potential risks, and support the assessment of additionality and permanence.

8.1. Farm-Level Baseline (Within the Project Area)

For each farm included, baseline characterization must cover land-use/land-cover mapping, GHG emissions, and estimates of carbon stocks.

8.1.1. Baseline Land Use and Land Cover Mapping

Land use and land cover must be mapped annually for each year of the five-year reference period, whenever possible. If land use remained stable during this period, mapping for the year immediately prior to the project start is sufficient. Mapping must prioritize high-resolution remote sensing datasets such as MapBiomas, Sentinel-2 mosaics, or ESRI base maps, and must be spatially aligned with the farm's official georeferenced boundaries. True-color (RGB) base maps may also assist in identifying land-use changes over time. When supervised classifications are employed, at a minimum the overall accuracy and the per-class confusion matrix must be reported, as well as the parameters/hyperparameters of the models used.

It is important to differentiate between land-use change (for example, forest converted to cropland) and management transitions (for example, renewal of coffee plantings within the same land-use category).

Required deliverables include:

• Maps illustrating the evolution of land use over the baseline period;

• A detailed polygon shapefile representing land-use types for the year immediately prior to the project start;

• A summary table quantifying total area (in hectares) for each land-use category.

The years analysed, collections/versions, and links to the datasets used must be provided to ensure traceability and reproducibility.

and-use categories to be mapped and reported include, where applicable: native vegetation (e.g., forests, savannas, wetlands), annual crops, perennial crops (e.g., coffee, citrus, cocoa, rubber, among others), pastures, and degraded/idle lands. Built infrastructure, water bodies, and environmental easement areas must likewise be mapped and reported when present; however, they are excluded from the quantification of emissions and removals (see **Section 7.1 "Spatial boundaries"**).

For perennial crops, different development stages must be mapped individually, even within the same cultivated species, to ensure accurate modelling of carbon sequestration rates. Landowners must also declare any land-use changes planned for the next five-year project cycle, including planned renewals, expansions, or land-use transitions. Planned changes are not credited until their effective verification in the MRV; the purpose is to plan scenarios and safeguards.

8.1.2. Baseline GHG Emissions

Baseline GHG emissions must be quantified in accordance with the project's carbon boundaries defined in **Section 7.3 "Carbon assessment: Sources, Sinks, and Pools"**. If farm management practices remained relatively stable during the five-year reference period, emissions may be assessed based on the most recent year prior to the project start. When the dynamics of farm activities involve significant changes in management practices over the years and this dynamic will continue into the next project cycle, a weighted average over the period must be calculated or appropriate adjustments must be justified. The quantification of emissions must be aligned with **Section 12 "Quantification of GHG Emissions**" in this methodology. Emission factors must be consistent with the IPCC Guidelines and/or national factors in force, with version and cut-off date recorded.

8.1.3. Baseline Carbon Stocks and Removals

Baseline carbon stocks must be quantified for all relevant carbon pools within the project area, as defined in **Section 7.3 "Carbon assessment: Sources, Sinks, and Pools"**. Stocks must be estimated and reported for native vegetation and perennial crops, even when not eligible for credit accounting. In perennial crops, absolute stocks (above- and belowground) are never eligible; accounting is limited to annual net removals, already net of management emissions. Even so, stocks are required inputs to: (i) calculate net removals from perennials (annual increment and pruning effects, with biomass disposition recorded); (ii) reconcile biogenic flows and verify permanence/reversals; and (iii) build the baseline and support annual MRV. In native vegetation, stock eligibility follows this methodology's criteria; when not eligible, they must still be reported to: (a) reconcile biogenic flows and verify permanence/reversals; and (b) build the baseline and support annual MRV.

If land use and management practices remained stable over the reference period (for example, no deforestation or degradation), carbon-stock estimates may be based on the most recent year prior to the project start. If the carbon-stock data for the last year are not available, data from the previous available year may be used, provided the substitution is clearly explained. For perennial crops already established before the start date, pre-project stock or removals are not credited; credits accrue to the net increment in biomass/stock observed after the start date.

The quantification of carbon stocks must follow the procedures and datasets described in **Section 13 "Quantification of Carbon Stocks and Removals"**. All parameters (for example, R:S ratios, biomass models, uncertainty bands) must have their source, version, and cut-off date recorded.

8.2. Reference Region Baseline

In addition to the farm-level baseline, projects must analyse trends and pressures on land use in the broader reference region defined during project design. This jurisdictional baseline provides critical context for assessing additionality and risks to the project's permanence.

The reference-region baseline must include an assessment of land-use and land-cover changes in the five years prior to the project start, using recognized public datasets such as MapBiomas and PRODES. The analysis must quantify regional rates of native-vegetation loss, degradation events (for example, occurrence of fires), and agricultural expansion or intensification. The data pipeline and treatment must be described in detail (for example, distinct resolutions of 30 m and 10 m, cloud/shadow masks, fire detection, product fusion), including the criteria, parameters, and thresholds adopted, as well as accuracy and validation metrics.

The regional baseline must serve the following purposes:

- Support additionality by demonstrating that the maintenance or improvement of carbon stocks represents a deviation from regional trends;
- Contextualize risks to permanence by characterizing broader pressures on similar land types outside the project area;
- Support the definition of conservative parameters for projections over the crediting cycle, aligned with safeguards against double counting and with integrity for possible use in insetting.

9. ADDITIONALITY

Unlike traditional methodologies that emphasize restoration to the detriment of conservation, this methodology departs from convention by recognizing that preserving well-managed ecosystems is, in itself, a high-impact climate action. It values the ongoing environmental stewardship carried out by landholders who maintain native vegetation and perennial systems—often without any compensation—challenging the notion that only newly restored areas are additional. This approach:

- Encourages sustainable production by rewarding producers for environmental preservation and climate action;
- Recognizes the ecosystem services provided by rural properties, such as the conservation of native areas and the adoption of good agricultural practices that contribute to GHG mitigation;
- Is legally grounded in the Brazilian Greenhouse Gas Emissions Trading System (SBCE, Law No. 15,042/2024) and in the National Policy on Payment for Environmental Services (PNPSA, Law No. 14,119/2021), which explicitly support activities that conserve and increase carbon stocks in biomass and in soils;
- Aligns with national priorities that promote low-carbon investments, the conservation of natural carbon stocks, and the integration of payments for environmental services through public or voluntary markets.

By prioritizing existing ecosystems, this methodology offers a more equitable and ecologically grounded definition of additionality, shifting the focus from “new trees planted” to the full climate and biodiversity value of avoided degradation and sustained stability. Landholders who already conserve native vegetation or maintain perennial systems—often facing economic, regulatory, and social barriers—become eligible for support via carbon-based climate finance.

Accordingly, additionality for projects under this methodology must be demonstrated through structured comparisons with reference regions and with the biome represented in the project area, considering spatial, temporal, climatic, and socioeconomic aspects. Each project must meet at least two of the criteria listed below, which must be substantiated by consistent evidence—spatial, operational, climatic, or socioeconomic—and apply to all areas included in the project, whether native vegetation, perennial crops, or both:

- **Regional Vulnerability to Anthropogenic Pressures:** Demonstrate that the project area lies within a territorial context subject to relevant pressures such as deforestation, forest degradation, recurrent fires, or the expansion of the agricultural frontier. The analysis must show, using public data (for example, MapBiomas, PRODES, BDQueimadas/INPE), that the reference region has recent rates of deforestation, degradation, and/or fire that are higher than those of adjacent regions and/or the respective biome, indicating above-average pressure.

- **Climate Vulnerability:** Demonstrate that the project area is exposed to increasing climatic pressures, such as droughts, heat waves, declining rainfall, or more frequent climate anomalies. Non-exhaustive signals may include detection of temperature/precipitation anomalies, lengthening of the dry season, an increase in consecutive rain-free days that affect vegetation, multi-year droughts, robust projections of rising temperatures and/or declining precipitation (for example, CMIP6-based studies), and records of El Niño/La Niña events associated with more severe stress in the region.

- **Regional Forest Deficit:** Demonstrate that the project helps reduce a known deficit of native vegetation or forest cover in the region. Although Brazil retains native cover over more than 60% of its territory, the distribution is highly heterogeneous: there are regions with low remaining cover and high fragmentation. Evidence showing the maintenance of remnants in areas with cover below the biome average or that of adjacent regions reinforces the additionality of prolonged conservation.

- **Social Vulnerability:** Demonstrate that landholders face elevated social or economic challenges, such as limited access to finance, infrastructure, or public incentives. Recognized indicators may be used (for example, IBGE/IDHM, municipal vulnerability indices, eligibility for programs such as PRONAF), as well as international references (for example, FAO/UN indicators of food security and rural livelihoods) and auditable local diagnostics. Evidence may also include socioeconomic profiles indicating family farming, reliance on agricultural activities as the household's primary source of income, or local interviews corroborating vulnerability.

• **Prolonged Conservation without Compensation and with Material Costs:** Demonstrate the continuous maintenance of native vegetation with recurring management and protection costs (for example, fencing, firebreaks, firefighting brigades, surveillance, maintenance of infrastructure) and the absence of equivalent remuneration mechanisms, evidencing that carbon finance is decisive to sustain future climate performance.

• **Coexisting Benefits for Ecosystems and Landscapes:** Demonstrate that project activities generate additional environmental gains (co-benefits) relative to predominant land uses in the region, including the maintenance or improvement of biodiversity, increased thermal and microclimatic stability, conservation and improvement of water availability, soil protection and restoration, and the strengthening of essential ecosystem services. Whenever applicable, factors such as presence in biodiversity hotspots, integration or strengthening of ecological corridors, and habitat connectivity must be analyzed. Consider landscape analyses (for example, functional connectivity, proximity and linkages to protected areas), accepting duly documented primary and secondary data. Provide site-specific evidence and bibliographic references to support conclusions.

For each selected criterion, the Project Design Document (PDD) must present the sources, data series, versions, and methods used, with version control and traceability. Additionality must be revalidated every crediting cycle (five years) or whenever there is a material change in context.

By requiring projects to demonstrate multiple lines of evidence for additionality, this methodology acknowledges the real challenges faced by landholders and rewards those who contribute significantly to climate mitigation and ecosystem resilience.

10. LEAKAGE EMISSIONS

In this context, “leakage” refers to unintentional increases in greenhouse gas (GHG) emissions outside the project implementation area that compromise the project’s net climate benefit. In conventional A/R and REDD+ projects that focus exclusively on carbon removals, leakage often occurs when landholders, after receiving credits for reforestation or conservation activities, shift their agricultural practices or selective logging to adjacent areas of native forest. To address these risks, international standards generally require the quantification of leakage through components such as activity shifting, foregone production, and market-induced effects.

This methodology does not quantify leakage emissions because the project design structurally minimizes leakage risk. This approach is aligned with CDM A/R Tool 15, which states:

- *“The displacement of an agricultural activity, by itself, does not result in leakage. Leakage occurs only when such displacement leads to an increase in GHG emissions relative to emissions within the project boundary.”*
- *“Secondary effects, such as changes in demand, supply, or the price of goods, are deemed insignificant and therefore accounted for as zero.”*

The methodology ensures negligible leakage through the following safeguard mechanisms:

I) **Comprehensive Farm Boundary:** the project boundary covers the entire rural property, including all agricultural areas (annual and perennial), pastures, native ecosystems, and built infrastructure—rather than isolating patches of native vegetation. By accounting for all land uses within a single farm, the risk of activity shifting is largely mitigated, since any land-use change remains internal and is fully tracked;

II) **Eligibility Filter:** to prevent indirect leakage, patches of native vegetation that have undergone land-use conversion through deforestation after 22 July 2008, pursuant to Article 68 of Law No. 12,651/2012 (Brazilian Forest Code), are excluded from the issuance of credits related to carbon stock. This filter avoids remunerating areas whose conversion may have triggered the indirect displacement of emissions;

III) **Comprehensive GHG Accounting:** all emission sources—including land-use change, agricultural activities, and managed areas—are monitored, reported, and included in the carbon balance. This project-wide accounting prevents leakage by ensuring that no change in emissions goes unrecorded;

IV) **Aligned Incentives:** farmers are incentivized not only for carbon removals (e.g., through reforestation projects) but also for conserving native vegetation, including mature forests where carbon sequestration rates may be lower. This approach reduces pressure to convert additional native vegetation.

11. RISKS AND PERMANENCE

Permanence in Agriculture, Forestry and Other Land Use (AFOLU) carbon credit projects refers to the long-term storage of carbon in vegetation and, where applicable, in soils and in other carbon sinks, with safeguards implemented to monitor, mitigate, and account for possible reversals over a defined time horizon. It is a foundational principle to ensure that climate-mitigation actions deliver lasting impacts. Traditionally, many methodologies define permanence as the requirement that carbon remain stored for 30, 50, or even 100 years, under the assumption that long-term stability guarantees environmental integrity.

However, these assumptions may be neither viable nor technically justified in a robust manner in light of the real conditions faced by landowners, project developers, and ecosystems. In regions exposed to wildfires, droughts, pests, political and economic changes, or shifts in land tenure and environmental laws, it is unrealistic to guarantee carbon storage for several decades. Even well-managed areas can be involuntarily lost due to natural disturbances or legally converted as a result of changes in ownership and regulatory shifts. Expecting permanence across generations—such as 100 years, which may encompass three or more ownership changes—is incompatible with the operational reality of most agricultural contexts.

Instead of projecting permanence into uncertain and distant futures, this methodology adopts a pragmatic approach. It focuses on delivering real, measurable, and verifiable climate benefits within clearly defined five-year crediting cycles, with independent annual verification (MRV). After each cycle, the carbon balance is fully reassessed with updated data, and only verified annual net benefits—after applying uncertainty deductions and in accordance with the technical buffer rules described in this section—are credited. This model enables frequent updates to baselines and land use, the timely incorporation of improved monitoring methods, and adjustments to credit issuance based on actual performance.

By prioritizing short-term integrity with a long-term perspective, this approach supports the urgent global priority of reducing deforestation and forest degradation, especially in tropical, high-pressure regions. It also helps shift the prevailing perception among landowners and stakeholders—many of whom still view standing forests and native vegetation as liabilities associated with tax burdens, legal obligations, and foregone income opportunities. By offering credible short-term compensation based on monitored carbon outcomes, the methodology reframes conservation as an economic opportunity rather than a cost.

This model aligns more effectively with the evolving global climate architecture, adopting the flexibility needed to incorporate future advances in remote sensing, carbon modeling, and land-management policies. It recognizes that tools and conditions will evolve—and that permanence should be grounded in what can be measured, monitored, and implemented today.

11.1. Assessment of Permanence Risks

Although this methodology reinterprets permanence through a practical, short-term lens, all projects are required to carry out annual assessments and to rigorously manage permanence risks throughout the entire five-year crediting period. The following principal risks are considered:

- **Natural Disturbances:**

Climate events such as wildfires, droughts, floods, and other extreme conditions can directly affect carbon stocks. While not all risks can be eliminated, projects are encouraged to adopt mitigation strategies, including firebreaks, near-real-time fire-alert services, and water-tanker use for immediate control of fire outbreaks, especially during critical periods.

- **Deforestation or Land-Use Reversal:**

If an area credited with carbon stocks or removals is deforested, degraded, or otherwise converted during the crediting cycle, the carbon credited for that area will be fully reversed and deducted from the total volume of credits issued in the period. Losses occurring before the close of the monitoring year are reflected in that year's balance; losses identified after the annual verification will be deducted in the subsequent cycle, without triggering the buffer.

- **Policy and Land Tenure Instability:**

Changes in governance, land tenure, or regulatory enforcement may affect a project's ability to maintain credited carbon. Credits are issued only when projects demonstrate clear legal control and verifiable monitoring capacity. If these conditions are disrupted, credit issuance will be suspended until compliance can be re-established.

11.2. Mechanisms to ensure permanence

To safeguard the environmental credibility of all credits issued, the methodology includes a robust set of mechanisms designed to protect carbon permanence:

- **Fixed Contribution to the Buffer Reserve:**

A fixed fraction of 5% of all verified carbon credits is allocated to a non-tradable buffer reserve. This reserve functions as a protection mechanism, providing a strategic safeguard to mitigate potential losses and preserve the integrity of the carbon-credit system. It maintains a stable stock that can be utilized in cases of reversals caused by natural or management-related factors. The buffer rate is fixed for all projects, ensuring consistency, transparency, and predictability.

- **Crediting Period Enforcement:**

Carbon benefits are assessed in defined five-year operational periods, with total carbon sequestration estimated for the full cycle. However, credits are not issued all at once: they are generated annually, and each year's issuance represents a proportional share of the total estimated carbon for that five-year cycle. Crucially, these annual credits are issued only after submission and successful verification of the annual monitoring report by a Validation and Verification Body (VVB). This structure ensures that credits reflect actual, verified performance, avoids over-crediting, and maintains a direct link between credit issuance and ongoing project monitoring. Issuance occurs exclusively on an ex-post basis, after the close of the monitoring year and independent verification.

- **Reissuance and Renewal Rules:**

At the end of each five-year period, projects may request a new crediting cycle. To do so, they must undergo a full baseline reassessment, update carbon-stock estimates, and account for any changes in land use, emissions, or ecological conditions. This approach values continuous performance rather than speculative permanence.

- **Loss Adjustment Clause:**

In the event of carbon loss during the crediting cycle—due to fire, unauthorized extraction without replacement, or land-use change in native areas—the credits corresponding to the affected area are deducted. This prevents the issuance of credits for carbon that is not durably stored or that has been prematurely released.

Taken together, these mechanisms support a model of permanence that is not pre-fixed, but continuous and enforceable, ensuring that only verified, monitored, and maintained carbon outcomes are rewarded. At the same time, the fixed buffer reserve and the reassessment framework protect the integrity of the system in the face of future uncertainties—allowing projects to adapt, evolve, and deliver climate value under real-world conditions.

12. QUANTIFICATION OF GHG EMISSIONS

This section describes the methods to estimate greenhouse gas (GHG) emissions from various potential sources within agricultural properties. The methodology is based on elements from the IPCC Guidelines for National Greenhouse Gas Inventories (2006; 2019 Refinement). Where necessary, equations and tables were adapted to the farm-level reality (since the original guidelines often apply to national inventories) or complemented with references from other sources, such as the Food and Agriculture Organization of the United Nations Statistical Division (FAOSTAT), to enhance the reliability and accuracy of GHG quantification in a simple, step-by-step framework.

The boundary of this methodology is defined as the “farm gate,” covering Scope 1 and Scope 2 emissions. Embodied emissions (Scope 3—such as fertilizer and pesticide production, feed production, and off-farm processing of animal products) are excluded. As per the GHG Protocol Land Sector & Removals Guidance, verified results may be used by buyers in their corporate inventories as Scope 3, Category 1 (purchased goods), without altering the project boundaries.

The methodology considers the following primary sources of GHG emissions from agricultural activities:

- Energy use;
- Fossil fuel use;
- Annual crops;
- Perennial crops;
- Biomass burning;
- Livestock

Although IPCC Volume 4 (Agriculture, Forestry and Other Land Use—AFOLU) provides standardized equations and emission factors for calculating emissions, projects may adopt alternative methodologies or integrate direct field measurements where appropriate. In such cases, projects shall provide full documentation detailing the sources and methods used, including a detailed explanation of procedures for direct field measurements, ensuring transparency, replicability, and consistency with internationally accepted carbon accounting practices.

To ensure accurate GHG calculations and support the certification process, farmers shall provide verifiable evidence of key operational data, such as the number of animals raised

on the properties, quantities of agricultural inputs used, and energy and fuel consumption. This requirement ensures process transparency, information traceability, and compliance with applicable carbon market standards. Where necessary, landowners may be asked to present documentation or records supporting these variables.
To ensure compatibility with insetting under the GHG Protocol and SBTi FLAG, the results in this section shall be presented as gross Scope 1 and Scope 2 emissions, reported separately from the Removals and Stocks modules. This separation is mandatory for corporate use (inventories and FLAG targets), preserving traceability by source and by management unit.

Emissions shall be reported disaggregated by gas (CO_2, CH_4, N_2O) and by emission source. Reporting shall present both mass values of each gas (t of CO_2, CH_4, N_2O) and CO_2e based on IPCC AR6 100-year global warming potentials (GWP100), as detailed in **Section 5.3 "GHG Metrics and Conversions".**

In addition to the absolute balance, it is recommended to publish an intensity table per productive hectare (tCO_2e/ha·year), disaggregated by emission source. This normalization facilitates performance comparisons across farms and over time, enabling the identification of outliers and trends. It also supports due diligence processes by providing standardized, verifiable metrics that increase transparency and comparability across assets, contribute to pricing by investors and buyers, and enable the use of results in FLAG targets.

12.1. Emissions from energy use

The main greenhouse gas (GHG) associated with energy use is carbon dioxide (CO_2). Emissions from electricity consumption can be calculated using:

$$E_{energy} = EC \times EF_{energy}$$

Where:

E_{energy} = total CO_2-equivalent emissions from electricity consumption (tonnes of CO_2e);

EC = energy consumed over one year (in MWh);

EF_{energy} = emission factor for the electricity consumed (tonnes of CO_2e per MWh).

Electricity consumed on Brazilian farms mainly comes from the national power grid. The annual emission factor of the Brazilian electricity mix shall be consulted in the *Sistema de*

Registro Nacional de Emissões (SIRENE[1]), administered by the Ministério da Ciência, Tecnologia e Inovação (MCTI), with explicit indication of the version and cut-off date of the factor used.

Where fossil-fuel generators are used, their emissions shall be calculated based on the equations and emission factors presented in the next section, "Emissions from fossil fuel use." Emissions from alternative energy sources, such as solar or wind, are considered negligible and therefore are not included in the emissions calculation.

12.2. Emissions from fossil fuel use

CO_2 is the main greenhouse gas emitted by the combustion of fossil fuels in agricultural activities, such as operating machinery for farm maintenance, crop management, and product transport. Emissions can be calculated by:

$$E_{fuels} = \sum FC_k \times EF_k$$

Where:

E_{fuels} = total CO_2-equivalent emissions from fossil fuel use (kg CO_2e);

FC_k = consumption of fuel type *k* over one year (liters);

EF_k = emission factor for fuel type k (kg CO_2/liter).

Emission factors may be obtained from sources such as the IPCC Guidelines (2006; 2019 Refinement), official national databases (MCTI/SIRENE), international reports such as the Department for Environment, Food & Rural Affairs—DEFRA (2021, United Kingdom), as well as peer-reviewed scientific articles, provided that the version and cut-off date are recorded.

12.3. Nitrogen fertilizer applications

N_2O is the main GHG emitted by most types of nitrogen fertilizers. For urea-based fertilizers, CO_2 is also emitted (addressed separately below). The first step in the calculation is to

[1] SIRENE provides annual CO_2 emission factors for electricity consumption, accounting for the country's entire energy grid mix, expressed in tonnes CO_2-equivalent per MWh. To convert kWh (as typically shown on energy invoices) to MWh, divide the value by 1,000.

identify all fertilizers used on the farm. Calculations shall be performed for annual crops, perennial crops, and pasture applications (where applicable). Where more than one crop is present (e.g., soybean and maize), emissions shall be calculated independently for each crop.

Phosphate and potash fertilizers that do not contain nitrogen are excluded from N_2O emission calculations. However, if a compound fertilizer contains any nitrogen component, it shall be included in the assessment. This methodology does not consider embodied emissions from fertilizer production (Scope 3, outside the “farm gate” boundary).

It is recommended to provide a table listing all fertilizers used, with chemical composition, total quantity applied, and nitrogen (N) content.

N_2O emissions include direct and indirect components. Direct emissions correspond to the conversion of nitrogen in soils, while indirect emissions result from leaching, surface runoff, volatilization, and subsequent redeposition. The calculations require determining the total nitrogen applied to soils from all synthetic and organic fertilizers.

12.3.1. Total Nitrogen applied

Once all fertilizers containing nitrogen have been identified, the next step is to calculate the total amount of nitrogen (N) applied to the soil, using:

$$TN_{fertilizers} = \sum_{f} TF_f \times NC_f$$

Where:

$TN_{fertilizers}$ = total nitrogen applied to the soil from all fertilizers (tonnes of N);

TF_f = mass of fertilizer type *f* applied (tonnes of product);

NC_f = nitrogen content of fertilizer type *f* (tonnes of N per tonne of product).

The N content (NC) may be obtained from product data sheets, official labels, or fertilizer leaflets, ensuring source and date traceability.

12.3.2. Direct N_2O Emissions

From the total nitrogen applied to the soil, direct N_2O emissions are calculated as:

$$E_{N_2O\ direct} = \sum_f (TN_f \times EF_f) \times \left(\frac{44}{28}\right)$$

Where:

$E_{N_2O\ direct}$ = direct N_2O emissions (tonnes of N_2O);

TN*f* = total nitrogen applied from fertilizer type f (tonnes of N);

EF*f* = emission factor for direct emissions specific to nitrogen application to managed soils (tonnes of N_2O-N per tonne of N applied);

44/28 = molecular weight ratio to convert N_2O-N to N_2O.

Emission factors for direct N_2O emissions may be obtained in IPCC (2019), Table 11.1. For humid climatic conditions, EF = 0.016 is recommended for synthetic fertilizers and EF = 0.006 for organic amendments.

12.3.3. Indirect N_2O Emissions: Leaching

Indirect N_2O emissions from nitrogen leaching are calculated according to Equation 11.10 of the IPCC (2019), Volume 4:

$$E_{N_2O\ leach} = \sum_f (TN_f \times F_{leach} \times EF_{leach}) \times \left(\frac{44}{28}\right)$$

Where:

$E_{N_2O\ leach}$ = total indirect N_2O emissions from leaching (tonnes of N_2O);

TN*f* = total nitrogen applied from fertilizer type *f* (tonnes of N);

F_{leach} = leaching factor for fertilizers (dimensionless);

EF_{leach} = emission factor for leaching/runoff (tonnes of N_2O-N per tonne of N);

44/28 = molecular weight ratio to convert N_2O-N to N_2O.

Emission factors for indirect N_2O emissions from leaching may be obtained in IPCC (2019), Table 11.3. For humid climatic conditions, F_{leach} = 0.24 and EF_{leach} = 0.011 are recommended.

12.3.4. Indirect N_2O Emissions: Volatilisation

Indirect N_2O emissions from volatilization and redeposition of nitrogen are calculated using Equation 11.11 of IPCC (2019), Volume 4:

$$E_{N_2O\ vol} = \sum (TN_f \times F_{vol,f} \times EF_{vol,f}) \times \left(\frac{44}{28}\right)$$

Where:

$E_{N_2O\ vol}$ = total indirect N_2O emissions from volatilization (tonnes of N_2O);

TN_f = total nitrogen applied from fertilizer type f (tonnes of N);

F_{vol} = volatilization factor for fertilizer type f (dimensionless);

EF_{vol} = emission factor for volatilization/redeposition (tonnes of N_2O-N per tonne of N);

44/28 = molecular weight ratio to convert N_2O-N to N_2O.

Emission factors and volatilization fractions may be obtained in IPCC (2019), Table 11.3. For humid climatic conditions, F_{vol} = 0.11 for synthetic fertilizers and 0.21 for organic amendments are recommended; EF_{vol} = 0.014.

12.3.5. Additional CO_2 Emissions from Urea fertilizers

Unlike other nitrogen-based fertilizers, urea releases not only N_2O but also CO_2 due to its carbon content. The carbon in urea is released as CO_2 during hydrolysis in the soil. CO_2 emissions from urea application are calculated using Equation 11.13 of IPCC (2006), Volume 4, based on the total amount of urea applied and its associated emission factor:

$$\mathrm{E_{CO_2\ urea}} = \sum (\mathrm{T_{urea}} \times \mathrm{EF_{urea}}) \times \left(\frac{44}{12}\right)$$

Where:

$E_{CO2\ urea}$ = total CO_2 emissions from urea fertilizers (tonnes of CO_2);

T_{urea} = total urea applied (tonnes of urea);

EF_{urea} = emission factor for CO_2 emissions from urea (tonnes of CO_2-C per tonne of urea);

44/12 = molecular weight ratio to convert CO_2-C to CO_2.

According to IPCC (2006), the recommended emission factor (EF_{urea}) is 0.20 tonnes of CO_2-C per tonne of urea applied.

12.4. Liming

CO_2 is the main greenhouse gas released when calcitic limestone ($CaCO_3$) is applied to neutralize soil acidity. CO_2 originates from the carbonate (CO_3^{2-}) component of limestone, which reacts in the soil environment. The calculation of these emissions requires determining the total amount of $CaCO_3$ applied, derived from the calcium (Ca) content in the liming material.

12.4.1. Total $CaCO_3$ applied

The total amount of calcitic limestone applied to the soil is calculated as:

$$T_{CaCO_3} = \sum_f TF_f \times CaC_f \times \left(\frac{100}{40}\right)$$

Where:

T_{CaCO3} = total amount of calcitic limestone applied (tonnes of $CaCO_3$);

TF_f = mass of fertilizer or amendment type *f* containing calcium (tonnes of product);

CaC_f = calcium content of that product (tonnes of Ca per tonne of product);

100/40 = molecular weight ratio to convert calcium (Ca) to $CaCO_3$.

The data source for calcium content (CaC_f) shall be recorded, including the version and cut-off date of the information consulted (e.g., data sheet, official label).

12.4.2. Total CO2 Emissions

CO_2 emissions from liming are calculated using Equation 11.12 of IPCC (2006), Volume 4:

$$E_{liming} = T_{CaCO_3} \times EF_{lime} \times \left(\frac{44}{12}\right)$$

Where:

E_{liming} = total CO_2 emissions from liming (tonnes of CO_2);

T_{CaCO3} = total calcitic limestone applied (tonnes of $CaCO_3$);

EF_{lime} = emission factor for CO_2 emissions from calcitic limestone (tonnes of CO_2-C per tonne of $CaCO_3$);

44/12 = molecular weight ratio to convert CO_2-C to CO_2.

The emission factor for calcitic limestone (EF_{lime}) is 0.12 tonnes of CO_2-C per tonne of $CaCO_3$ applied, as defined in IPCC (2006), Volume 4.

12.5. Crop residue management

GHG emissions from crop residue management refer to the emissions associated with the decomposition of plant material remaining in the field after harvest or crop maintenance. Residues are classified as follows:

- Aboveground residues, such as stalks, leaves, seed pods, and husks;
- Belowground residues, including root systems and associated structures

When residues are retained in the field—whether left on the surface, incorporated into the soil, or used as mulch—they contribute to nitrogen inputs that may result in direct and indirect N_2O emissions. These emissions depend on the crop type, biomass quantity, and nitrogen content.

As outlined in the IPCC 2006 and 2019 Guidelines, CO_2 emissions from residue decomposition are excluded from quantification, as they are derived from recently assimilated atmospheric carbon and are considered part of the biogenic cycle.

This methodology estimates GHG emissions from residues using default parameters and formulas from IPCC (2019), Volume 4, Chapter 11 (Equations 11.6 and 11.7). Where available and verifiable, direct field measurements or alternative validated estimation methods (e.g., slope-intercept models) may be used.

Residues that are burned or removed from the system are not covered by this section. These cases require specific emission factors and must be addressed using a separate methodology (see Section 12.6 – Biomass Burning). It is important to note that crop residue burning is not a common practice in Brazil, particularly in mechanized and conservation-oriented production systems.

12.5.1.1. Step 1: Gather Crop-Specific parameters

For each annual crop cultivated, collect the following data. Default values (except for Yield freshT that highly differs among farms) are available in Table 11.1a of IPCC (2019). Yield freshT data must be provided by the project proponent.

- Yield $fresh_T$: Fresh yield of crop *T* (kg fresh weight per ha)
- DRY_T: Dry matter content of crop *T* (kg dry matter per kg fresh weight)
- RAG_T: ratio of aboveground residue dry matter to harvested yield for crop *T* (dimensionless)
- RS_T: ratio of belowground biomass to aboveground biomass for crop *T* (dimensionless)
- NAG_T: Nitrogen content of aboveground residues for crop *T* (kg N per kg dry matter)
- NBG_T: Nitrogen content of belowground residues for crop *T* (kg N per kg dry matter)

12.5.1.2. Step 2: Calculate Biomass of Residues

Using the variables from Step 1, estimate total aboveground and belowground biomass of crop residues for each crop using the following formulas:

$$Crop_T = Yield\ Fresh_T \times DRY_T$$

$$AG_{DM,T} = Crop_T \times RAG_T$$

$$AGR_T = AG_{DM,T} \times Area_T$$

$$BGR_T = \left(Crop_T + AG_{DM,T}\right) \times RS_T \times Area_T$$

Where:

$Crop_T$ = harvested dry matter yield for crop T (kg dry matter per ha)

$AGDM_T$ = aboveground residue dry matter for crop T (kg dry matter per ha)

$AGR_{(T)}$ = annual amount of aboveground crop residue for crop T (kg dry matter per year)

$BGR_{(T)}$ = annual total amount of belowground crop residue for crop T (kg dry matter per year)

$Area_T$ = total annual area harvested of crop T (ha per year)

12.5.1.3. Step 3:Estimate Total Nitrogen in Residues

Using the variables from Step 1 and 2, estimate the amount of N in residues from the sum of above- and below-ground content a:

$$NR_T = AGR_T \times N_{AG(T)} + BGR_T \times N_{BG(T)}$$

Where:

NR_T = total nitrogen in residues for crop T (kg N per year)

12.5.1.4. Step 4: Calculate N_2O Emissions from Residue Nitrogen

Estimate total direct and indirect N_2O emissions using the following IPCC-based equations:

$$L_{residue,\ N2O\text{-}soil} = \left(\left(NR_T \times EF_1\right) + \left(NR_T \times EF_5 \times Frac_{LEACH\text{-}(H)}\right)\right) \times \frac{44}{28}$$

$$L_{residue} = L_{residue,\ N2O\text{-}soil} \times GWP_{N2O}$$

Where:

EF_1 = Direct N_2O emission factor from residues (dimensionless)

EF_5 = Indirect N_2O emission factor from leaching/runoff (dimensionless)

$Frac_{LEACH-(H)}$ = fraction of nitrogen lost through leaching (dimensionless)

44/28 = Molecular weight conversion from N_2O–N to N_2O

GWP_{N2O} = Global Warming Potential of N_2O

Emission factors are taken from IPCC (2019), Tables 11.1 and 11.3. For wet climate conditions, the direct N_2O emission factor (**EF_1**) is 0.006, and the indirect emission factor from leaching and runoff (**EF_5**) is 0.011. The leaching fraction ($Frac_{LEACH-(H)}$) is set at 0.24.

12.6. Biomass Burning

This section refers to the combustion of organic material resulting from agricultural and industrial activities carried out within the farm, including the burning of crop residues, the use of wood products in boilers, and the operation of dryers for seed processing, as well as other applications related to bioenergy production.

Biomass burning resulting from wildfires in native vegetation is not addressed in this section but rather in the specific chapter on "Quantification of carbon stocks and removals," since it involves calculations directly linked to carbon stock estimates, including the processing of satellite imagery and the use of vegetation indices.

Greenhouse gas (GHG) emissions from this type of burning consist mainly of methane (CH_4) and nitrous oxide (N_2O). Although carbon dioxide (CO_2) is also released, it is conventionally excluded from the calculations because it represents biogenic carbon recently removed from the atmosphere through photosynthesis, as established in the IPCC Guidelines (2006; 2019 Refinement).

It should be noted that when burning does not occur and wood from perennial species is exported from the farm for external use (for example, in pulp and paper industries or for energy generation outside the project boundary), such emissions are not accounted for in this methodology, as they fall outside the boundary defined as the "farm gate."

Total emissions are estimated using the following equations:

$$E_{burn,CH_4} = TB_{burn} \times EF_{burn,CH_4}$$

$$E_{burn,\ N_2O} = TB_{burn} \times EF_{burn,\ N_2O}$$

Where:

$E_{burn,\ CH4}$ = total CH_4 emissions (tonnes of CH_4)

$E_{burn,\ N_2O}$ = total N_2O emissions (tonnes of N_2O)

TB_{burn} = total biomass burned (tonnes of biomass)

$EF_{burn,\ CH4}$ = emission factor for CH_4 from biomass burning

$EF_{burn,\ N_2O}$ = emission factor for N_2O from biomass burning

Applicable emission factors may be obtained from IPCC (2019), Table 2.5. For humid climatic conditions, it is recommended to use $EF_{burn,\ CH_4}$ = 0.0027 kg CH_4/kg biomass burned and $EF_{burn,\ N_2O}$ = 0.00007 kg N_2O/kg biomass burned.

12.7. Emissions from livestock

This methodology considers the following sources of GHG emissions from livestock:

- Enteric fermentation;
- Manure management;
- Application of fertilizers on pastures

The main greenhouse gases associated with livestock are methane (CH_4) and nitrous oxide (N_2O). CO_2 emissions are not estimated, since the net annual CO_2 emissions from livestock are considered negligible according to the IPCC Guidelines (2019), Volume 4. CH_4 is emitted by enteric fermentation and, to a lesser extent, by manure management. N_2O is emitted by manure management through direct emissions (nitrification and denitrification processes) and indirect emissions (volatilization and leaching). Whenever pastures are fertilized (use of lime and fertilizers), these emissions must be estimated. All emissions must first be reported in their respective gases (tonnes of CH_4 or N_2O), and then converted to CO_2 equivalents using Global Warming Potentials (GWP, see **Section 5.3 "GHG Metrics and Conversions"**).

12.7.1. Step 1: Description of animal populations

An inventory with the characterization of the animal population is essential to ensure an accurate estimate of GHG emissions from livestock. Emission factors vary according to species, category, production system, feeding regime, and manure management practices. Therefore, all relevant information may be collected at the farm level to correctly apply Tier 1 or Tier 2 factors, in accordance with the IPCC Guidelines (2019), Volume 4.

Species and subcategories

All animals must be classified by species and productive category, in accordance with the IPCC Guidelines (2019), Volume 4, Table 10.1, or with FAOSTAT data (the FAO's global statistical database for agriculture and livestock). For Brazilian properties, the most common categories include: cattle (beef and dairy), buffalo, poultry (broilers, laying hens, turkeys, and ducks), swine (market and breeders), equines (horses, donkeys, and mules), sheep, and goats.

Although not mandatory, it is recommended to provide additional details whenever available: herd structure (sex, age, and average live weight) and productivity systems (classification into high or low productivity). These details allow for more accurate application of specific factors for each animal and align the methodology with IPCC Table 10.1. Emission factors by species, category, sex, and age (e.g., young or mature animals) can be obtained from the supplementary tables of IPCC Volume 4 (2019), which accompany the official supporting material.

Average annual population

The average annual population is defined as the average number of animals of each species and category present on the farm over a 12-month period. The estimation method depends on whether the population is:

- **Static populations:** for animals that remain on the farm throughout the year (e.g., dairy cows, breeding sows, laying hens), the annual population is simply the number of animals recorded in the herd inventory.

- **Populations with short production cycles (fattening/finishing):** for animals raised for meat, the population often changes because animals are usually raised for only part of the year before being sold or slaughtered. To account for this, the average annual population must reflect the average number of animals present on the farm at any given time.

The following equation is recommended (according to Equation 10.1 of the IPCC Guidelines 2019, Volume 4) to estimate the average annual population for growing animals:

$$N_T = Days_{alive} \times \frac{NAPA_T}{365}$$

Where:

N_T = average annual population of species/animal category T

$Days_{alive}$ = average number of days an animal remains on the farm

$NAPA_T$ = total number of animals produced annually

For example, a farm that raises broilers for about 40 days before slaughter. If that farm produces 80,000 broilers annually, the average annual population would be 8,767 broilers.

Live weight

For each animal category, the average live weight (kg) may be reported. This is essential to estimate nitrogen excretion and methane emissions. When available, it is recommended to use actual farm data; otherwise, reference values from Table 10.5 of the IPCC Guidelines (2019), Volume 4, or FAOSTAT may be adopted.

Feeding system

Feeding conditions influence enteric fermentation emissions, especially for ruminants. According to Table 10.5 of the IPCC Guidelines (2019), Volume 4, two main situations are defined:

- **Confinement**: animals are kept in pens or barns with little energy expenditure to obtain feed (e.g., swine, poultry, confined dairy cows).
- **Pasture/Grazing area**: animals graze and expend energy foraging.

For poultry and swine, the standard considered is confinement. Additional classifications may be used when necessary, consulting the latest IPCC tables.

Manure management system (MMS)

The manure management system determines the CH_4 and N_2O emission factors for each animal category, according to storage, treatment, and deposition. This must be specified at the farm level, with classification based on Table 10.18 of the IPCC Guidelines (2019), Volume 4. Common systems include:

- **Pasture/Grazing area/Corral**: manure excreted directly in the field, unmanaged.
- **Daily spread**: manure removed daily and applied to cropland or pastures.
- **Lagoons, pits, composting, dry lots, and others**: applicable to operations with confined animals.

The proportion of animals in each management system must be reported to correctly allocate emissions from storage and treatment processes.

12.7.2. Step 2: CH_4 emissions from enteric fermentation

Enteric fermentation is a natural digestive process that occurs in ruminant systems (such as cattle, sheep, and goats) and, to a lesser extent, in non-ruminants. This process results in methane (CH_4) emissions, with emission factors generally expressed in kg CH_4/head/year.

CH_4 emissions from enteric fermentation are calculated in accordance with Equation 10.19 of the IPCC Guidelines (2019), Volume 4:

$$CH_{4,enteric} = \sum (EF_T \times N_T)$$

Where:

$CH_{4,enteric}$ = methane emissions from enteric fermentation for category T (kg CH_4/year);

EF_T = emission factor for animal category T (kg CH_4/head/year);

N_T = average annual population of animal category T.

In the absence of farm-specific data (Tier 2), Tier 1 values from the IPCC (2019, Volume 4, Supplement) may be used, which provide regional average factors. For Latin America, for example, the average reference values for non-dairy cattle are found in the supplementary file “Tables10.A.2–3_non-Dairy_Cattle.xlsx,” with factors expressed in kg CH_4/head/year.

When available, regional data or farm data (feed intake, live weight, and herd productivity) must prevail, allowing for more representative Tier 2 estimates.

12.7.3. Step 3: CH_4 emissions from manure management

Methane (CH_4) is produced when manure decomposes under anaerobic conditions, i.e., in the absence of oxygen. This process occurs mainly in confinement systems, such as dairy farms, beef feedlots, swine and poultry operations, especially when manure is stored or treated in liquid form (lagoons, tanks, pits, or biodigesters). Conversely, manure managed as solid (stockpiled, composted) or deposited directly on pastures tends to decompose under aerobic conditions, resulting in lower CH_4 emissions.

CH_4 emissions from manure management are calculated in accordance with Equation 10.23 of the IPCC Guidelines (2019), Volume 4:

$$CH_{4,manure} = \sum (EF_T \times N_T)$$

<u>Where:</u>

$CH_{4,\ manure}$ = methane emissions from manure management for animal category T (kg CH_4/year);

EF_T = emission factor specific to manure management for animal category T (kg CH_4/head/year);

N_T = average annual population of animal category T.

Selection of the emission factor must consider the manure management system (MMS) used in each category, according to Table 10.17 of the IPCC Guidelines (2019), Volume 4. In the absence of field data, regional Tier 1 values provided by the IPCC (2019, Volume 4, Supplement) may be applied, which provide averages for Latin America and other regions.

12.7.4. Step 4: N_2O emissions from manure management

Nitrous oxide (N_2O) from manure management results from direct and indirect emissions. In pasture-based systems—predominant in Brazil, where more than 90% of cattle are managed in this way (Anualpec, 2022)—direct deposition on soil is the main source of N_2O. In confined systems (for example, swine or confined cattle), manure is collected and treated, modifying CH_4 and N_2O fluxes.

Adaptation of formulas

The original IPCC equations were designed for national inventories. Here, they are applied in simplified form, suitable for the farm level. Parameters such as Tdays/365 were fixed at 365 days (continuous grazing), AWMS was assumed to be 1.0 in full pasture systems, and Ncdg(S) (nitrogen from external codigested substrates in biodigesters) was considered zero.

The annual nitrogen excretion per head (Nex, kg N/year) can be obtained from the IPCC Guidelines (2019), Volume 4, Table 11.1, for each animal category. When available, it can also be calculated from live weight and volatile solids (VS), according to Table 10.13a. The AWMS parameter was assumed to be 1.0 in full pasture systems, but must be adjusted according to the MMS declared for confined systems. Although this methodology seeks to reflect the predominant reality in the country, more specific formulas (Tier 2) may be used whenever robust field data are available, provided that full documentation is presented and originates from recognized sources.

Direct N_2O emissions from manure management

Direct emissions are calculated as (adaptation of Equation 10.25 of the IPCC Guidelines 2019, Volume 4):

$$E_{N_2O\ direct} = \left(\sum_T N_T \times Nex_T \times EF_3 \right) \times \frac{44}{28}$$

<u>Where:</u>

$E_{N2O\ directa}$ = direct N_2O emissions (kg N_2O/year);

N_T = number of animals in category T;

Nex_T = average annual N excretion per animal of category T (kg N/head/year);

EF_3 = direct emission factor (kg N_2O–N/kg N excreted);

44/28 = conversion from N_2O–N emissions to N_2O emissions.

For humid climate conditions, the IPCC (2019) recommends EF3 = 0.006 for pasture systems.

Indirect N_2O emissions – volatilization pathway

First, volatilized nitrogen is calculated (adaptation of Equation 10.26 of the IPCC Guidelines 2019, Volume 4):

$$N_{vol} = \sum_{T} N_T \times Nex_T \times \text{Frac}_{\text{GasMS(T)}}$$

This value is converted into N_2O emissions (adapted from Equation 10.29):

$$E_{N_2O\,vol} = N_{vol} \times EF_4 \times \frac{44}{28}$$

Where:

N_{vol} = nitrogen volatilized (kg N/year);

N_T = number of animals in category T;

Nex_T = average annual N excretion per animal of category T (kg N/head/year);

$Frac_{GasMS(T)}$ = fraction of nitrogen volatilized for animals of category T (dimensionless);

EF_4 = emission factor for N_2O from volatilized nitrogen (kg N_2O–N/kg N volatilized);

44/28 = conversion factor from N_2O–N to N_2O.

Standard values for FracGasMS and EF4 can be obtained from Table 10.22 (Chap. 10) and Table 11.3 (Chap. 11) of the IPCC Guidelines (2019), Volume 4.

Indirect N_2O emissions – leaching pathway

First, leached nitrogen is calculated (adaptation of Equation 10.27 of the IPCC Guidelines 2019, Volume 4):

$$N_{leach} = \sum_{T} N_T \times Nex_T \times \text{Frac}_{leach\text{MS(T)}}$$

This value is converted into N_2O emissions (adapted from Equation 10.29):

$$E_{N_2O\ leach} = N_{leach} \times EF_5 \times \frac{44}{28}$$

Where:

N_{leach} = nitrogen lost through leaching and runoff (kg N/year);

N_T = number of animals in category T;Nex_T = excreção média anual de N por animal da categoria T (kg N/cabeça/ano);

Nex_T = average annual N excretion per animal of category T (kg N/head/year);

$Frac_{leach\ MS(T)}$ = fraction of nitrogen leached for animals of category T (dimensionless);

EF_5 = emission factor for N_2O from leached nitrogen (kg N_2O–N/kg N leached);

44/28 = conversion factor from N_2O–N to N_2O.

Standard values for $Frac_{leachMS}$ and EF_5 can be obtained from Table 10.22 (Chap. 10) and Table 11.3 (Chap. 11) of the IPCC Guidelines (2019), Volume 4.

Final conversion to CO_2e

After obtaining the values in N_2O (direct, volatilization, and leaching), apply the Global Warming Potential (GWP) to express the results in tonnes of CO_2 equivalent (t CO_2e).

12.7.5. Fertilizer application on pastures

When pastures are fertilized with nitrogen-based products, the associated GHG emissions are accounted for as part of the total livestock emissions, since fertilization is directly linked to soil management in support of animal production. These emissions have the same biological origin as nitrogen applications in croplands, involving mainly direct and indirect N_2O fluxes generated by soil microbial activity.

In such cases, emissions may be quantified following the procedures and equations already described in this methodology, in particular **Sections 12.3 "Nitrogen fertilizer applications" and 12.4 "Liming".** This includes identifying all fertilizers used, calculating the total amount of nitrogen applied, and estimating both direct and indirect N_2O emissions, as well as any additional CO_2 emissions from liming, using emission factors provided in the IPCC Guidelines (2006; 2019 Refinement).

13. QUANTIFICATION OF CARBON STOCKS AND REMOVALS

This section presents the general guidance for estimating carbon stocks and removals within the project area, covering two main pools:

- **Native vegetation** (e.g., forests, savannas, natural ecosystems): estimation of initial stocks and additional removals is mandatory, preferably using recognized datasets and remote-sensing-derived models.
- **Long-lived perennial crops** (e.g., coffee, citrus, cocoa, rubber, among others): estimation must be performed when present within the project area. Only net removals (biomass accumulation over time) are creditable and may be estimated via raster modelling or species-specific allometric equations.

The methodology follows the IPCC Guidelines (2006; 2019 Refinement) and international best practices for carbon certification, prioritizing scalable, remote-sensing-based approaches to ensure scientific robustness, transparency, and verifiability. Permanent/temporary plot data may be used as a complementary source, provided sampling, metadata, and traceability are documented for audit. For each dataset/model used, it is mandatory to record: name, source, version, cut-off date, CRS, resolution, resampling method, and version-controlled scripts.

13.1. Native vegetation

The quantification of aboveground biomass (AGB) stocks in native vegetation should preferably rely on remote-sensing products that combine optical, LiDAR, radar observations, and calibration with field data. These products provide scalability, comparability across biomes, and the potential for continuous monitoring throughout the project cycle.

13.1.1. Step 1: Global/National Raster Datasets

Suitable datasets include, but are not limited to: Global Forest Watch biomass and canopy-height maps, NASA GEDI (Global Ecosystem Dynamics Investigation) L4A biomass layers, the ESA CCI (European Space Agency) Biomass product, and biomass maps based on national forest inventories, where available.
Preferred datasets must have a spatial resolution of 30 meters or finer and must fully cover all native vegetation areas within the project boundary. Where high-resolution datasets (<30

m) are not available for parts of the project area, datasets with resolutions up to 100 meters may be used to ensure complete spatial coverage. These datasets offer crucial advantages:

- **Spatial and temporal coverage:** their high resolution and regular updates enable detection of subtle structural changes and support long-term monitoring.
- **Standardization:** harmonized production methods ensure consistency across biomes, projects, and regions, facilitating national alignment and international comparability.
- **Transparency and efficiency:** open-access and peer-reviewed sources increase methodological credibility, reduce bias, and streamline third-party verification.

To ensure spatial consistency and comparability across datasets, project proponents must perform rigorous geospatial preprocessing, including aligning all raster layers, reprojecting to a common Coordinate Reference System (CRS), and resampling where necessary. When integrating datasets with different spatial resolutions, the resampling methods must be fully described.

From the selected rasters, the project proponent must develop a spatial model to estimate AGB across the full extent of native vegetation. This model must integrate recognized AGB reference datasets with remote-sensing-derived variables to generate a continuous, high-resolution biomass raster. These models—described in **Section 13.1.2 "Step 2: Generation of High-Resolution Aboveground Biomass (AGB) Layers for Full Coverage"** —should combine inputs such as spectral bands, vegetation indices, and elevation. The modelling process must be fully documented, and all model outputs must include accuracy metrics to ensure transparency, reproducibility, and third-party verification.

13.1.2. Step 2: Generation of High-Resolution Aboveground Biomass (AGB) Layers for Full Coverage

To ensure full spatial coverage and continuous monitoring, spatial models must be developed to fill any gaps not covered by high-resolution datasets and to generate biomass estimates across the entire extent of native vegetation. These models must not only support baseline estimation, but also enable the calculation of annual carbon removals and aboveground biomass (AGB) losses due to fire, degradation, or land-use change over the project cycle.

This modelling capability is especially critical when original reference datasets are no longer updated or suffer publication delays—conditions that could compromise monitoring continuity and timely credit issuance. Thus, spatial models must rely on consistently available and temporally dynamic input variables capable of capturing short-term fluctuations in biomass structure and condition.

The modelling process must be based on input variables with demonstrated correlation to forest structure and carbon density. These may include, but are not limited to:

- Spectral bands and vegetation indices (e.g., NDVI, EVI, NBR) from Sentinel-2 imagery;
- Radar backscatter and structural indices (e.g., VV, VH, RVI) from Sentinel-1;
- Topographic variables such as elevation, slope, and aspect obtained from Digital Elevation Models (DEMs), such as SRTM and ALOS.

These variables must be used to train a predictive model using statistically robust techniques, such as multiple linear regression, Random Forest, or other machine-learning algorithms. The model must be calibrated against pixel-aligned values from the selected AGB reference rasters, ensuring consistency with recognized biomass estimates. Minimum model requirements include:

- Generation of a continuous AGB raster in tonnes per hectare (t AGB/ha);
- Spatial resolution of 30 meters or finer;
- Use of appropriate training and validation methods (e.g., cross-validation, separate validation set);
- Reporting of model accuracy metrics, including:
  - Coefficient of determination (R^2);
  - Mean Absolute Error (MAE);
  - Root Mean Square Error (RMSE).

Project documentation must include:

- Data sources and acquisition dates;
- Complete list of input variables;
- All preprocessing steps;
- Modelling algorithm and parameter settings;

- Validation methods and results.

The resulting model must provide continuous and consistent AGB coverage for all native vegetation within the project boundary and follow the conservative accounting principles defined in this methodology. All input data, intermediate layers, trained models, and validation datasets must be preserved and made available to the Validation and Verification Body (VVB) for audit and verification.

Once the spatial model or dataset provides a complete AGB raster for all native vegetation areas, total AGB must be calculated. To minimize the influence of extreme values—common in biomass distributions—the median pixel value should be used instead of the mean. Total AGB is then calculated as:

$$AGB_{total,i} = AGB_{median,i} \times Area_i$$

Where:

$AGB_{total,i}$ = Biomassa total acima do solo para o tipo de vegetação i (toneladas de AGB)

$AGB_{median,i}$ = Valor mediano dos pixels do raster de AGB para o tipo de vegetação i (toneladas de AGB por hectare)

$Area_i$ = Área total do tipo de vegetação i (hectares)

13.1.3. Step 3: Belowground Biomass (BGB) and Total Biomass (TB)

After estimating aboveground biomass (AGB), belowground biomass (BGB)—another essential component of the ecosystem carbon cycle (Warren et al., 2015)—must be calculated. BGB includes plant biomass located underground, primarily root systems (coarse and fine roots). Measuring BGB is challenging due to physical inaccessibility (requiring excavation or coring) and the complexity of root structures (roots vary widely in size, type, and structure) (Mokany et al., 2006). As a result, BGB is generally estimated using a standard root-to-shoot ratio (R:S) that ranges between 0.20 and 0.25 (IPCC, 2006, 2019).

However, studies indicate that R:S varies widely across regions and vegetation types (Spawn et al., 2020). Global patterns suggest greater biomass allocation to roots in water- and nutrient-limited environments, such as savannas, with some R:S values exceeding 1 (meaning BGB surpasses AGB) (Mokany et al., 2006; Zhou et al., 2022). Proponents may use alternative ratios from peer-reviewed sources (e.g., Mokany et al., 2006; Spawn et al., 2020) appropriate to the regional context. The calculation is:

$$BGB_{total,i} = AGB_{total,i} \times RS_i$$

Where:

$BGB_{total,i}$ = Total belowground biomass for vegetation type iii (tonnes BGB)

$AGB_{total,i}$ = Total aboveground biomass for vegetation type iii (tonnes AGB)

RS_i = Root-to-shoot ratio for vegetation type iii (dimensionless)

The sum of above- and below-ground biomass represents total vegetative biomass:

$$TB_{total,i} = AGB_{total,i} + BGB_{total,i}$$

13.1.4. Step 4: Carbon Fraction and Total Carbon Stock

To estimate the amount of carbon stored in total biomass, a carbon fraction (CF)—representing the proportion of carbon contained in dry vegetation biomass—is applied. The IPCC provides a widely accepted default value of 0.47, meaning that 47% of dry biomass is assumed to be carbon (IPCC, 2006, Vol. 4, Table 4.3; unchanged in the 2019 Refinement). This value is based on extensive research and serves as a reliable default in the absence of more specific data.

For greater accuracy, proponents may use species- or region-specific carbon fractions derived from peer-reviewed scientific literature. In such cases, the data source must be clearly cited to ensure transparency and credibility.

$$TC_{total,i} = TB_{total,i} \times CF_i$$

Where:

$TC_{total,i}$ = Total carbon stock for vegetation type *i* (tonnes C)

$TB_{total,i}$ = Total biomass for vegetation type *i* (tonnes biomass)

CF_i = Carbon fraction for vegetation type *i* (tonnes of carbon per tonne of biomass, dimensionless)

13.1.5. Step 5: Estimates of Carbon Removals

To estimate carbon removals from native vegetation areas, the focus is on quantifying net biomass gains over time. Annual carbon removals must be estimated using consistent spatial datasets or models capable of tracking biomass changes during a defined baseline period. Although a minimum period of five years is required, longer time series are encouraged to improve robustness.

One possible approach involves generating a time series of annual AGB rasters for the five years preceding the project start date. These rasters must be derived from the same spatial model used for AGB estimation (see **Section 13.1.2 Step 2**) and updated with consistent remote-sensing inputs—such as Sentinel-1 and Sentinel-2 imagery—ensuring methodological continuity across years. This approach enables the direct detection of annual changes in AGB and supports transparent and dynamic carbon accounting.

Annual changes in AGB are then converted into carbon removals by applying the standardized procedures described in Steps 3 and 4 (**Sections 13.1.3 and 13.1.4)**, including estimating belowground biomass (BGB) via the root-to-shoot ratio and applying the appropriate carbon fraction. The final result is an annualized carbon removal value, expressed in tonnes of carbon per hectare per year (t C/ha/yr).

Alternatively, some global datasets—such as ESA CCI Biomass, Global Forest Watch (GFW), or NASA GEDI L4A—may include modelled estimates of net AGB change over time. When such datasets are used to infer annual removals, the following conditions must be met:

- The underlying assumptions and model structure must be clearly described;
- The temporal resolution and update frequency must align with the project's baseline period;
- The spatial resolution and extent must be compatible with the project boundary;
- Any limitations, smoothing algorithms, or data gaps must be documented.

Regardless of the selected method, carbon removal estimates must be underpinned by full technical documentation and transparent reporting. The following materials must be submitted as part of the verification package:

- Description of input datasets and temporal coverage;
- Explanation of the modelling algorithm or data product used for year-on-year AGB estimation;

- Calculation protocol for deriving annual removals (including BGB and carbon fraction steps);
- Table summarizing annual AGB, BGB, and carbon stock values for each of the five years;
- Final time series of annual removal values (t C/ha/yr) for each homogeneous vegetation area.

13.1.6. Step 6: Model-Based Uncertainty deductions

Uncertainty deductions apply to the final total carbon stock (TC), after the complete estimation of AGB, BGB, and carbon-fraction conversions, as well as to carbon removals (sequestration). This ensures that quantified carbon reflects not only methodological rigor but also the reliability of the underlying spatial model.

For this purpose, the Root Mean Square Error (RMSE) derived from the final AGB model must be used. RMSE quantifies the average magnitude of prediction errors in biomass estimation and is preferred over Mean Square Error (MSE) because it is interpretable in the same units as AGB (tonnes per hectare). To standardize deductions across projects, a Relative Uncertainty Ratio (RUR) is calculated as follows:

$$RUR_{TC,i} = \frac{RMSE_{AGB,i}}{AGB_{median,i}}$$

<u>Where:</u>

$RUR_{TC,i}$ = Relative uncertainty ratio applied to total carbon stock for vegetation type *i* (dimensionless)

$RSME_{AGB,i}$ = Root Mean Square Error of the AGB model for vegetation type *i* (tonnes AGB per ha)

$AGB_{median,i}$ = Median pixel value of the AGB raster for vegetation type *i* (tonnes AGB per ha)

Higher RUR values indicate less reliable estimates. Based on the RUR, the following deduction tiers must be applied to the total carbon stock (TC) prior to credit issuance: Use the RUR-based uncertainty thresholds (Table 2) to assign the appropriate deduction tier to the Total biomass stocks (TC).

Table 2. Deduction Tiers for Total carbon stocks and removals based on Relative Uncertainty Ratio (RUR)

Mean RUR (per homogeneous area)	Interpretation	Deduction Applied to TC
≤ 0.25	Low uncertainty	5% deduction
> 0.25–0.50	Moderate uncertainty	10% deduction
> 0.50–1.00	High uncertainty	15% deduction
> 1.00	Very high uncertainty	20% deduction

Alternative approaches—such as Monte Carlo simulations, Bayesian uncertainty propagation, or ensemble prediction intervals—may also be used in place of the RUR, provided they are fully documented, including assumptions, algorithms, data sources, and final uncertainty estimates.

It is also recommended that proponents compare estimated carbon stocks or removals with secondary national-level datasets, such as Brazil's National GHG Inventory or the Nationally Determined Contributions (NDCs), as reported to the UNFCCC. In addition, proponents may present model performance when applied to secondary datasets or scientific literature (e.g., regional inventories, peer-reviewed AGB estimates). While optional, this step provides additional credibility to biomass quantification and reinforces the basis for conservative yet fair deductions.

The following documentation must be submitted for third-party verification: Final RMSE value used in the RUR calculation

- Median AGB values per homogeneous vegetation area
- Final RUR values and associated deduction tiers applied
- Clear traceability to the AGB raster, including resolution, version, and model inputs.

13.1.7. Step 7: Quantification of Carbon Losses from natural burned areas

In addition to accounting for carbon stocks and removals, this methodology provides a standardized approach to quantify carbon losses resulting from natural fire events that impact native vegetation areas. These losses must be calculated whenever fire events are detected during the crediting period, as they represent reversals of previously quantified AGB and associated carbon stocks.

Detection of Burned Areas

Burned areas must be detected using remote-sensing data with sufficient spatial and temporal resolution to capture sudden vegetation losses. Proponents are encouraged to use Sentinel-2 imagery and fire-focused indices such as:

- Normalized Burn Ratio (NBR), delta NBR (dNBR) and Normalized Difference Vegetation Index (NDVI)
- Burned Area Index (BAI)
- NASA FIRMS active fire detections
- MapBiomas Fire Layers and INPE Queimadas data, where available.

These datasets and indices must be used to delineate the extent and timing of burned patches within the project's native vegetation areas. Detected fires must be classified by date, location, and affected vegetation type.

Quantification of Biomass Losses

To estimate carbon loss resulting from fire events, the methodology requires comparing pre- and post-fire biomass levels in the affected area using the project's AGB model. Specifically:

- AGB_{before} must correspond to the most recent available AGB raster prior to the fire event.
- AGB_{after} should be derived from updated post-fire imagery, using the same modelling approach as in Step 2.

$$AGB_{loss,i} = AGB_{before,i} - AGB_{after,i}$$

<u>Where:</u>

$AGB_{loss,i}$ = Aboveground biomass loss for vegetation type i (tonnes AGB)

$AGB_{before,i}$ = Aboveground biomass before the fire or disturbance event for vegetation type i (tonnes AGB)

$AGB_{after,i}$ = Aboveground biomass after the fire or disturbance event for vegetation type i (tonnes AGB)

This biomass loss must then be converted to total carbon loss by following the same procedures outlined in Steps 3 and 4 **(Sections 13.1.3 e 13.1.4)**. Specifically, the AGB loss is used to estimate belowground biomass (BGB) using a root-to-shoot ratio (RS), and the combined biomass loss (AGB + BGB) is multiplied by the carbon fraction (CF) to obtain the total carbon loss (TC_{loss}), expressed in tonnes of carbon (t C).

13.2. Carbon Removals in Perennial Crops

This section describes the methodology for quantifying carbon removals from long-lived perennial crops such as coffee, citrus, cocoa, rubber trees, among others. In contrast to native vegetation, only net carbon removals—i.e., the increase in biomass occurring during the crediting period—are eligible for crediting in perennial systems. Existing carbon stocks at the start of the project are not considered creditable under this methodology.

Quantification of carbon removals in perennial crops may follow one of two primary approaches:

- **Spatial Modelling via Remote Sensing:** Uses raster-based predictions derived from satellite imagery, vegetation indices, and machine-learning models to estimate annual biomass changes across the landscape.
- **Species-Specific Allometric Equations:** Uses peer-reviewed mathematical models that estimate biomass accumulation based on plant characteristics such as age and planting density.

Regardless of the chosen pathway, the method must:

- Be crop-specific and based on scientifically validated sources;
- Ensure full spatial coverage of relevant perennial crop areas within the project boundary;
- Support the generation of annual carbon removal estimates over a minimum period of five years (baseline monitoring period);
- Be fully documented and reproducible for validation and verification purposes.

The following steps describe the procedures for implementing each approach, including data requirements, model structure, biomass-to-carbon conversions, and uncertainty deductions.

13.2.1. Approach 1: Spatial Biomass Modelling for Perennial Crops

Some perennial crops—especially those with widespread cultivation and structural heterogeneity, such as coffee, citrus, and rubber trees—may be partially represented in regional or global biomass datasets. These include NASA GEDI (Global Ecosystem Dynamics Investigation) L4A biomass products and the ESA CCI Biomass dataset. Where applicable, such datasets may serve as the initial reference layer for Aboveground Biomass (AGB), provided that:

- The data are filtered to include only areas mapped as perennial crop plantations, using validated land-use classifications;
- The dataset provides sufficient spatial and temporal consistency to support annual carbon removal estimation.

If no suitable dataset exists or coverage is incomplete, a dedicated spatial model must be developed to estimate AGB specifically for perennial crops. The modelling process should follow the same structure used for native vegetation (see Section 13.1.2), with the important distinction that the model must be trained only on pixels known to represent perennial crop types.

The model must be trained using input variables with a demonstrated relationship to perennial-crop biomass. These typically include:

- Spectral bands and vegetation indices from Sentinel-2 imagery, as indicated for native vegetation;
- Radar backscatter and vegetation-structure indicators from Sentinel-1, as indicated for native vegetation;
- Topographic variables derived from Digital Elevation Models (DEMs).

The final model must generate a continuous raster of AGB with units expressed in tonnes of AGB per hectare (t AGB/ha). This raster must provide full spatial coverage of perennial planting areas within the project boundary and must allow generation of annual time-series layers.

Once annual AGB estimates have been generated, the project must proceed to convert them into total carbon stock following the same procedures established for native vegetation. This includes estimating belowground biomass using species-specific root-to-shoot ratios, computing total biomass as the sum of above- and belowground components, and applying a carbon fraction to convert total biomass to carbon stock. Species-specific values must be applied.

The spatial biomass model must be validated using statistically robust methods equivalent to those required for native vegetation. This includes cross-validation techniques and reporting model accuracy using RMSE. Relative Uncertainty Ratios (RUR) must be calculated and used to assign uncertainty-deduction tiers. All uncertainty deductions must follow the same structure and thresholds defined for native vegetation in Step 6 (**Section 13.1.6**). Complete documentation of model inputs, validation metrics, and deduction levels must be included in the project submission.

All input data, modelling scripts, intermediate rasters, and documentation must be preserved and submitted for third-party verification. The model must also be replicable and transparent, with full traceability of input variables and assumptions.

13.2.2. Approach 2: Species-Specific Allometric Equations

As an alternative to spatial modelling, carbon removals from perennial crops may be quantified using species-specific allometric equations. These equations estimate aboveground biomass (AGB) based on crop growth characteristics and are particularly suitable for managed plantation systems where species, spacing, and tree development patterns are relatively uniform.

Most allometric models for perennial systems express AGB as a function of plant age and tree density—two variables that can typically be obtained from planting records, time-series imagery, or remote-sensing analysis. Some models may also incorporate plant height, stem diameter, or crown dimensions, depending on crop type and data availability. These equations often follow a power-law or exponential form, reflecting the natural growth curve of long-lived crops, in which biomass accumulates rapidly at early stages and gradually stabilizes as trees reach maturity.

To apply the allometric approach, the following steps must be followed:

- Select an appropriate equation from peer-reviewed scientific literature or credible technical guidelines. The equation must be calibrated for the specific crop species and regional conditions (e.g., climate, management system). The methodology described in the *Quantification Methodology and Accounting Framework for Carbon Sequestration in Perennial Cropping Systems* (Cool Farm Alliance & Quantis, 2022) is recommended, as it provides validated equations for common crops such as coffee, citrus, and cocoa;

- Determine plantation age and tree density for each plot or management unit. These data may be extracted from farm records, detected via satellite-based time series of vegetation indices, or visually interpreted from high-resolution imagery. If other structural variables (e.g., height, crown diameter) are required by the equation, they must be obtained with equivalent methodological rigor;
- Estimate per-tree AGB using the selected equation and calculate total AGB per hectare by multiplying by tree density and by the corresponding area of each homogeneous crop unit.

Once AGB has been calculated, the procedure follows the same steps defined for native vegetation:

- Estimate belowground biomass (BGB) using a species-specific root-to-shoot ratio (RS);
- Combine AGB and BGB to compute total biomass (TB);
- Apply a species-specific carbon fraction (CF) to convert total biomass into carbon stock.

This method is particularly advantageous for perennial crops such as coffee, citrus, cocoa, and rubber, where growth rates and biomass development are well studied and management practices are consistent. It allows precise estimates of annual carbon removals, since only net biomass accumulation beyond the initial baseline is eligible for crediting.

Project proponents must ensure transparency by providing:

- The full source and mathematical form of the allometric equation used;
- Validation statistics from the original study (e.g., R^2, RMSE, number of observations);
- Plantation age, tree density, and other input data used in the calculation;
- Any adjustments made to adapt the equation to the project area or conditions.

Proponents must quantify the uncertainty associated with the selected allometric equation used to estimate AGB. This is essential to ensure that carbon removals are conservatively accounted for and reflect the reliability of the underlying model. Uncertainty must be derived from one or more of the following sources:

- Standard Error of the Estimate (SEE) or Root Mean Square Error (RMSE) reported in the original peer-reviewed publication or technical reference;
- Confidence intervals around predicted AGB values, especially across the range of plant ages or sizes;
- Uncertainty in input variables, particularly plant age and tree density, when these are estimated via remote sensing or historical records rather than direct field measurement.

If the original publication does not provide RMSE or similar metrics, the proponent must attempt to reconstruct them based on available data. This may include:

- Deriving RMSE using reported R^2 values and residual standard deviation; or
- Calculating relative error percentages for common plantation ages using validation data presented in the source.

If none of these approaches is feasible due to lack of data or documentation, the methodology requires that a default uncertainty deduction of **20%** be applied to the estimated carbon removals. This reflects a high-uncertainty level and aligns with the precautionary principle.

All supporting materials, calculations, and assumptions must be transparently documented and submitted as part of the project appendix.

14. CALCULATION OF ANNUAL CREDITS AND RISK BUFFER

This section sets out how to convert the final estimates of stocks, removals, and emissions into tradable annual credits. All values below must have been previously adjusted by the uncertainty deductions defined in this methodology and already converted to tCO_2e. The equation for the property's annual net balance is defined as:

$$Credits_{year} = \left(\frac{Stock_{initial}}{20} + Removals_{year} - Emissions_{year}\right) \times (1 - Buffer_{risk})$$

The parameters of the equation are described below:

Annual credits:

Total carbon credits (tCO_2e) for the respective year, resulting from the net balance among estimated emissions, removals, and stocks.

Carbon stock of native vegetation:

The stock component corresponds to the total **eligible** carbon in native vegetation existing at the start of the project, approved as to eligibility. This stock is converted into a flow of twenty equal annual instalments, calculated as $tCO_2e/20$. Annual release is conditioned on demonstrating maintenance of the stock in the period of each report, through annual MRV (measurement, reporting and verification). Adopting twenty years serves essential functions: (i) it distributes recognition of the service over a horizon compatible with agroforestry and perennial-crop operational cycles; (ii) it avoids front-loaded issuance and reduces exposure to ex-post revisions, anchoring issuance to performance verified annually; (iii) it improves financial predictability for small and medium producers by transforming a single stock into an auditable multi-year flow; (iv) it reduces dependence on very long speculative horizons, replacing them with periodic proof of maintenance of effectively stored carbon. Initial stocks of perennial crops are not creditable.

Annual removals:

These involve carbon sequestration from native vegetation areas and perennial crops. Because they are annual metrics, they are fully added to the year's total credits and must be reported separately (native and perennial).

Annual emissions:

The sum of all GHG emissions resulting from productive activities within the farm (project Scopes 1 and 2), including CH_4 and N_2O from burning events in native vegetation when they occur; biogenic CO_2 associated with stock loss is treated in the "eligible stock" component (to avoid double counting).

Buffer risk:

The positive annual result before the buffer is the portion of the year's stock (described above) plus annual removals minus emissions. When this result is negative, no credits are issued in the year; the treatment of reversals follows the specific chapter of this methodology (**Section 11.2**). From the positive annual result, a 5% risk reserve (buffer) is applied in a non-tradable account. The remainder constitutes the total credits issued for the reference year, pursuant to the equation above.

All calculations must be fully reproducible by an independent verifier, based on primary inputs (rasters, models, validation time series, and operational records), with an annual memorandum specifying: (i) the portion of stock released; (ii) removals considered; (iii) emissions deducted; (iv) the amount allocated to the risk buffer; and (v) references for version/cut-off date/CRS/resampling and script versioning.

15. MONITORING PLAN

The Monitoring Plan defines the procedures, responsibilities, tools, and quality-assurance mechanisms required to verify the dynamics of carbon stocks and removals, GHG emissions, and non-permanence risks throughout the project's crediting period. It ensures the environmental integrity of credits issued under this methodology and supports compliance with MRV requirements under national and international standards.

A complete Monitoring Plan—including all methods used and the corresponding results—must be submitted annually as part of the Project Monitoring Report (PMR). This report underpins credit issuance and must reflect the most recent data available, updated land-use conditions, and any reversals or disturbances identified. The plan and results must record, for each input/model, the source, version, cut-off date, CRS, resolution, resampling method, and versioned scripts.

15.1. Scope of Monitoring, method and frequency

Monitoring shall be conducted across the entire accounting area of the project, as defined in **Section 7 "Project Boundaries"** of this methodology. For each of the components listed below, the Monitoring Plan must clearly specify the method used and the applicable frequency. All methods must be consistent with the quantification procedures, uncertainty deductions, and crediting conditions established by this methodology.

- **Land Use/Land Cover (LULC) classification**

Must be based on spatial analysis using optical or radar satellite imagery, or equivalent geospatial products. The plan must describe the classification method, spatial resolution, period covered, and the approach to accuracy assessment.

- **Detection of land-use disturbances (e.g., fire, deforestation, degradation)**

Monitoring must include detection of abrupt vegetation loss or structural changes via multitemporal imagery or equivalent tools. The plan must define how disturbance events are identified, mapped, and used to update the area eligible for credit generation.

- **Quantification of GHG emissions from agricultural activities**

Must use activity data collected at the property level (e.g., fuel use, fertilizer application, livestock) and apply standardized emission factors aligned with IPCC methodologies. All assumptions must be clearly stated.

- **Estimation of above-ground biomass (AGB), below-ground biomass (BGB), total biomass, and carbon in native and perennial vegetation**

Must rely on spatial models derived from remote sensing or stratified estimation frameworks. The plan must document input variables, model structure, spatial coverage, and associated uncertainty metrics.

- **Calculation of net GHG emissions and removals**

Must combine spatial estimates of carbon stocks with agricultural emissions to produce a net carbon balance. The method must include all required deductions (e.g., reversals, buffers, uncertainties) and be documented transparently.

- **Assessment of non-permanence risks and reversals**

Must include systematic spatial tracking of risks such as fire or land-use change. The plan must define how these events trigger adjustments to credited areas or deductions to net removals.

- **Model-based uncertainty assessment**

All biomass models must include uncertainty analysis using the standardized procedures described in **Section 13 “Quantification of Carbon Stocks and Removals”** of this methodology. The plan must describe how deduction levels are determined and applied to reduce the risk of over-crediting.

15.2. Responsibilities and Team Structure

The Monitoring Plan must clearly identify all individuals or teams responsible for each component of the monitoring process. For each function involved—such as remote-sensing analysis, biomass estimation, or data management—responsibilities must be explicitly described. All monitoring data must be archived electronically for at least five years after the end of the project's last crediting period.

15.3. Methodological Deviations

In exceptional cases, deviations from the procedures prescribed in this methodology may occur. Such deviations must be formally documented, justified, and verified, ensuring that the project's environmental integrity, conservativeness, and transparency are preserved.

To be considered valid, deviations must be clearly described and justified in the Monitoring Report. The justification must demonstrate that:

- **Conservativeness is maintained:** The deviation cannot result in the underestimation of GHG emissions or the overestimation of carbon stocks or removals.
- **Scope is appropriate:** Deviations are confined to methodological elements or, on an exceptional and duly justified basis, to other essential aspects, always conditioned upon maintaining conservativeness and traceability and upon formal approval by the **Validation and Verification Body (VVB)**.
- **ransparency is ensured:** All assumptions, data sources, and expected impacts of the deviation must be traceable and clearly reported.

Examples of acceptable deviations include, but are not limited to:

- Use of higher-resolution spatial datasets, provided there is documentation of cross-calibration with the original source;
- Updates to modeling parameters or assumptions based on peer-reviewed scientific literature, with justification of greater accuracy or conservativeness;
- Application of updated root-to-shoot ratios specific to local conditions or crop types, provided they are scientifically validated.
- Only deviations that meet these criteria and receive formal approval from the VVB may be applied in the issuance of credits.

15.4. Products of the Methodology: Reporting Structure

This methodology adopts a standardized reporting system throughout the project life cycle. All reports must be submitted in digital format (PDF), accompanied by structured appendices containing shapefiles, raster maps, data tables, and all documentation necessary to validate and verify carbon credits.

Report Type	Description	Frequency	Conditions
Project Design Document (PDD)	Defines project eligibility, boundaries, baseline, demonstration of additionality, monitoring plan, and applicable quantification rules	Once, at project start	May be combined with the first monitoring report if submitted together
Project Monitoring Report (PMR)	Presents monitoring results, net-carbon calculations, quantification methods, and credit estimates	Annual	Mandatory for credit issuance. Includes activity data, carbon stocks and removals, and GHG emissions
Validation and Verification Report (VVR)	Independent assessment prepared by the VVB to verify the information in the **PDD** or PMR	Annual (for PMR) / Once (for **PDD**)	Must be submitted after each monitoring report or initial validation
Consolidated Validation and Monitoring Report (PVMR)*	Optional report combining **PDD** and PMR when both are prepared together for the first submission	One-time, at project registration	Applicable only if the project has completed the first monitoring cycle prior to registration

Note: Initial submissions may consolidate the **PDD** and PMR into a PVMR, provided that eligibility criteria and verified monitoring data are ready at the time of registration.

15.4.1. Project Design Document (PDD) Structure

The PDD is submitted for formal validation of the project. It must demonstrate that participating properties, landowners, the parties involved—and the project as a whole—meet the applicability conditions and the requirements set forth in this methodology. The document must provide a complete and transparent view of the project design, its eligibility, and the expected climate benefits, enabling the VVB to assess the credibility of boundaries, baseline, additionality, monitoring approach, and long-term risk management.

Section	Description
Executive Summary	Brief description of the project, objectives, and targeted ecosystem services
Project Proponent	Organization responsible for implementation
Entities Involved	Financing partners, technical or operational support
Stakeholders	Identification of impacted and interested parties
Eligibility Criteria	Justification in accordance with regulations and the methodology
Project Boundaries	Delimitation of the Project Area, Reference Region, Native Vegetation Areas, and other applicable zones
Baseline Scenario	Historical description of land use, carbon stocks, removals, and GHG emissions
Demonstration of Additionality	Demonstration based on the methodology's tool, with spatial, operational, climatic, or socioeconomic support and alignment with SBCE (Brazilian Emissions Trading System) and PNPSA (National Policy on Payment for Environmental Services)
Monitoring Plan	Monitoring strategy, including methods, tools, uncertainty management, and indicators to be tracked
Appendices	Supporting documents, tables, raster maps, shapefiles, and data used for analysis and for requesting credits

15.4.2. Project Monitoring Report (PMR) Structure

The PMR presents the verified results of each monitoring cycle and constitutes the basis for carbon-credit issuance. It must demonstrate that monitoring activities were carried out as planned and that any changes, reversals, or deductions were duly accounted for.

The PMR must be submitted annually, no later than six months after the close of each credit year, once the carbon balance for the preceding period has been established.

Section	Description
Executive Summary	Verified climate benefits, monitoring results, and credit performance during the period
Monitoring Period and Activities	Dates and scope, description of activities carried out, land-use changes, and operational adjustments
Carbon Stocks and Removals	Quantitative results for above-ground and below-ground biomass, including deductions and uncertainty estimates
GHG Emissions	Emissions from agricultural activities (e.g., fuels, fertilizers, livestock), calculated according to the methodology's methods
Net-Carbon Calculation	Final balance of emissions and removals, with application of deduction factors, uncertainty levels, and non-permanence buffers

Buffer and Reversals	Documentation of losses due to fire, deforestation, or degradation, with corresponding deductions or reversal of credits
Verification Evidence	Imagery, local data, scientific articles, uncertainty assessments
Geospatial and Documentary Evidence	Satellite images, spatial analyses, accuracy reports, and bibliographic sources used

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