METHODOLOGICAL DOCUMENT
AFOLU SECTOR

BCR0002
Quantification of GHG Emission Reductions REDD+ Projects

BIOCARBON CERT®

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Acronyms and abbreviations

AFOLU	Agriculture, Forestry and Other Land Uses
AB	Aboveground biomass
A/R (AR)	Afforestation and reforestation
AE	Annual emission
BB	Belowground biomass
BT	Total biomass
BCC	Biomass carbon content
CDM	Clean Development Mechanism
CF	Carbon fraction of the dry matter
CH_4	Methane
CO_2	Carbon dioxide
CO_{2e}	Carbon dioxide equivalent
CT	Total carbon dioxide equivalent; $tCO2e\ ha^{-1}$
FAO	Food and Agriculture Organization of the United Nations
FSC	Change in the surface covered by forest
GHG	Greenhouse Gases
GIS	Geographic Information System
IPCC	Intergovernmental Panel on Climate Change
N_2O	Nitrous oxide
REDD+	Reducing Emissions from deforestation, forest degradation and forest conservation, sustainable management or enhancement of forest carbon stocks.
SOC	Soil organic carbon
QA/QC	Quality Control/Assurance Control
UNFCCC	United Nations Framework Convention on Climate Change
VCC	Verified Carbon Credits

1 Introduction

This methodology provides to the REDD+ projects holders the best practices on procedures, models, parameters, and data to quantify and monitor GHG emission reductions attributable to project activities that avoid the unplanned deforestation and enhance the carbon stock of forests that would be deforested under the baseline scenario.

Eligibility to apply this methodology requires evidence that forest cover within the project boundary has remained effectively stable, showing no significant net loss, for a continuous period of at least ten years immediately preceding the project start date.

This methodology encompasses the complete REDD+ project framework, covering: (i) definition of eligible activities; (ii) specification of spatial and temporal boundaries; (iii) identification of drivers and agents of deforestation and degradation; (iv) baseline scenario determination and demonstration of additionality; (v) quantification and treatment of uncertainty; (vi) calculation of mitigation outcomes; (vii) management of risk, leakage, and non-permanence; and (viii) compliance with REDD+ safeguards. The methodology has no geographical limitations and is globally applicable.

This methodology sets out the procedures for quantifying historical deforestation and forest degradation in line with the requirements for calculating emission reductions attributable to REDD+ projects. Project holders may elect to include or omit specified carbon pools in the quantification, provided that each decision is fully justified and applied consistently throughout the project.

Project holders may submit methodological deviations to adjust the estimation of emission reductions to specific project characteristics as long as the approval process by BIOCARBON CERT [1] is completed.

This Methodology shall be used by the REDD+ project holders to be certified and registered with the BCR STANDARD.

[1] If applicable, prior to validation of the REDD+ project, the project holder shall submit a detailed proposal for methodological deviation that includes an analysis in compliance with a) the principles set forth in ISO 14064-2:2019; numeral 3, or that which updates it and b) the requirements of applicable national legislation. BIOCARBON REGISTRY will review the proposal and if it contains sufficient information for the evaluation, will assign an expert for the review. The outcome of the review will indicate whether the methodological deviation is feasible and the additional aspects to be included in the final version of the project document.

2 Objectives

The objectives of this methodological document (from now on referred to as this methodology) are:

(a) establish rigorous procedures and data requirements for quantifying the net greenhouse-gas (GHG) emission reductions and removals attributable to REDD+ project activities, fully aligned with IPCC guidance and the rules of the relevant carbon-crediting program;

(b) specify the criteria and step-wise approach for constructing a credible baseline scenario, including selection of the reference period and region, data sources, recalibration intervals, and quality-control checks, against which project performance will be assessed;

(c) define the monitoring and follow-up requirements for forest-cover change, carbon-stock variation in relevant pools, socio-environmental safeguards, and data QA/QC, together with the reporting formats and third-party verification procedures;

(d) establish procedures for assessing, quantifying, and mitigating both market and activity-shifting leakage, as well as non-permanence risk, including the calculation of buffer-reserve deductions and periodic risk reassessment;

(e) provide guidance for project-level accounting, ensuring consistency of activity data and emission factors, avoiding double counting, and facilitating transparent aggregation of results;

(f) facilitate alignment and articulation of the project accounting with national (or jurisdictional) REDD+ accounting frameworks, where applicable, to ensure methodological consistency and prevent double counting.

3 Version and validity

This document constitutes the public consultation draft of Version 4.1, dated May 19, 2025.

4 Scope

This methodological provides the basis and requirements for quantifying emission reductions and for the monitoring of REDD+ project activities, included in the AFOLU sectoral scope.

This methodology is limited to the following REDD+ activities:

(a) Emission reduction from unplanned deforestation;

(b) Emission reduction due to forest degradation.

Project holders will have to use this methodology for certification and registration under the BCR STANDARD.

5 Applicability conditions

This methodology is applicable under the following conditions:

(a) the areas in the project boundaries correspond to the forest category (as outlined by the national forest definition for the Clean Development Mechanism), at the start of the project activities and minimum ten years before the project start date;

(b) The forest areas located within the project boundaries can include different successional forest types, each of them considered as different strata, such as mature, secondary, degraded, planted and others;

(c) the project areas shall exclude wetlands or peatlands category;

(d) the identified causes of unplanned deforestation may include, among others, expansion of the agricultural frontier, mining, timber extraction, and infrastructural expansion;

(e) the causes of forest degradation identified may include selective logging, fuelwood extraction, forest fires and forest grazing;

(f) no reduction in deforestation or forest degradation is expected to occur in the baseline scenario of the Project;

(g) the carbon stock in the Soil Organic Carbon, the litter and deadwood pools may decrease or remain stable in the project scenario;

(h) Emissions from non-CO_2 caused by forest fires, gases shall be included in the monitoring period.

6 Normative references

The following references are indispensable for the implementation of this Methodology:

(a) BCR STANDARD, in its most recent version;

(b) the guidelines, other orientations, and guides defined by BIOCARBON CERT, in the framework of GHG projects;

(c) the IPCC Guidelines for National Greenhouse Gas Inventories (2006 and 2019). Volume 4. Agriculture, Forestry and Other Land use;

(d) the applicable national legislation, relating to GHG projects.

This methodology uses the latest versions of the follow tools:

- Baseline scenario and additionality: BCR guidelines baseline and additionality, v 1.4, May 7, 2025.
- Safeguards: Tool to demonstrate compliance with the REDD+ safeguards, v 1.1, January 26th, 2023.
- Sustainable Development Goals (SDG): BCR_SDG-tool
- Risk analysis of non-permanence tool: Permanence and Risk Management Version 2.0, April 17, 2025

7 Terms and definitions

Additionality

It is the characteristic that allows demonstrating that the reductions of GHG emissions or removals derived from implementing a GHG project activity generate a net benefit to the atmosphere in terms of reduced or removed GHG emissions.

Those GHG emission reductions project holders demonstrate that would not occur in the absence of the project are considered additional, as described in section 9 of this document.

Source: Adapted from the Glossary CDM terms. Version 10.0.

Agriculture, Forestry and Other Land Use (AFOLU)

The sector comprises either greenhouse gas emissions or removals attributable to project activities in agriculture, forestry, and other land uses.

Activity data

Data on the magnitude of human activity resulting in emissions or removals taking place during a given period of time. In the LULUCF sector, data on land areas, management systems, lime and fertilizer use are examples of activity data[2].

Baseline scenario

The baseline scenario is the most reasonable scenario that would occur in the absence of the project's activities and represents all the variations of the carbon stocks pools, included in the project boundaries.

Source: Adapted from the Glossary CDM terms. Version 10.0

Carbon fraction

Tons of carbon per ton of dry biomass, in the case of AFOLU projects.

Carbon pools

A compartment in which carbon stock changes occur in terrestrial ecosystems (tree aboveground biomass, tree belowground biomass, non-tree aboveground biomass, non-tree belowground biomass, deadwood, litter, soil organic matter), as defined in the Guidelines of the Intergovernmental Group of Experts on Climate Change (IPCC) for national greenhouse gas inventories.

Deforestation

Deforestation is defined as the direct or induced conversion of forest cover to another type of land cover in a given period. Once the parameters applicable to the forest definition have been defined, the forest boundaries can be identified at any time. Only areas within these boundaries can be subject to deforestation activities. Consequently, "forested areas" that do not meet the minimum conditions for the country-specific definition of forest cannot be deforested.[3]

Units of land can only be classified as deforested if they have been subject to direct human-induced conversion from forest to non-forest land. Areas in which forest cover was lost as a result of natural disturbances are therefore not considered deforested, even if changed physical conditions delay or prevent regeneration, provided that these changes in physical conditions are not the result of direct human-induced actions. If, however, the natural

[2] https://www.ipcc.ch/site/assets/uploads/2018/03/GPG_Sp.pdf
[3] https://www.ipcc.ch/site/assets/uploads/2018/03/GPG_LULUCF_FULLEN.pdf

disturbance is followed by a non-forest land use, then this will prevent the regeneration of forest, and the deforestation shall be considered direct human induced.

Deforestation agents

Individuals, social groups, or institutions (public or private) that, influenced or motivated by a series of factors or underlying causes, decide to convert natural forests to other land cover and land uses, and whose actions are manifested in the territory through one or more direct causes.

Direct causes of deforestation

Direct causes of deforestation[4] are related to human activities that directly affect forests. They include factors that operate at the local scale, different from the initial structural or systemic conditions, which originate in land use and affect forest cover by harvesting the arboreal resource or eliminating it to give way to other uses.

Eligible areas

Areas that meet the definition of forest on the reference dates established by the BCR STANDARD. The areas in the project boundaries that correspond to the category of natural forest (as outlined by the national forest definition for the Clean Development Mechanism), at the beginning of the project activities, and minimum ten years before the starting date of the Project.

Forest (Natural Forest)

"Forest" is a minimum area of land of 0.05-1.0 hectares with tree crown cover (or equivalent stocking level) of more than 10-30 per cent with trees with the potential to reach a minimum height of 2-5 meters at maturity in situ. A forest may consist either of closed forest formations where trees of various stores and undergrowth cover a high proportion of the ground or open forest. Young natural stands and all plantations which have yet to reach a crown density of 10-30 per cent or tree height of 2-5 meters are included under forest, as are areas normally forming part of the forest area which are temporarily unstocked as a result of human intervention such as harvesting or natural causes, but which are expected to revert to forest.[5]

[4] In the most national and international studies, the term "direct cause" is equated with the concept "driver" of deforestation.
[5] The Marrakech Accord. CP7/D11. https://unfccc.int/sites/default/files/resource/docs/cop7/13a01.pdf. The project holder shall use the definition that applies.

Forest degradation

Degradation is indicated by a negative trend in land condition, caused by direct or indirect human-induced processes, such as animal grazing, fuel-wood or timber extraction, or other similar activities. Degradation is expressed as the long-term reduction or loss of at least one of the following: biological productivity, ecological integrity, or human values. This definition applies to both forest land and non-forest land. Forest degradation is land degradation in forest remaining forest. In contrast, deforestation refers to the conversion of forest to non-forest that involves a loss of tree cover and a change in land use.[6]

In addition to this definition, the application of this methodology shall take into account the characterization of forest degradation as defined by the IPCC: A direct, human-induced, long-term loss (persisting for X years or more) or at least Y% of forest carbon stocks [and forest values] since time T and not qualifying as deforestation. [7]

Project activity

Activity or activities that alter the conditions of a GHG baseline emissions and which cause GHG emission reductions or GHG removal enhancements.

[SOURCE: ISO 14064-3:2019(en), 3.4.1.]

Leakage Areas

Potential emissions that occur in the leakage areas outside the project boundaries due to the activity displacement from the baseline deforestation agents. Leakage means the net change in anthropogenic emissions by sources of greenhouse gases (GHG) that occurs outside the project boundary and is measurable and attributable to the project activity.

Non-forest

Land that is without forest cover in a minimum period of 10 years and cannot support trees or was previously an arboreal cover but changed to a different cover. It includes commercial forest plantations, palm crops, and trees planted for agricultural production.

[6] In the SRCCL definition. https://www.ipcc.ch/site/assets/uploads/sites/4/2019/11/07_Chapter-4.pdf
[7] Definitions and Methodological Options to Inventory Emissions from Direct Human-induced Degradation of Forests and Devegetation of Other Vegetation Types (IPCC, 2003)

Organic soils

According to FAO (definition adopted by IPCC)[8], they are soils with organic carbon content equal to or greater than 12%. Organic soils (e.g., peat and manure) have at least 12 to 20 percent organic matter by mass and thrive under poorly drained wetlands conditions.

Organic soils are identified based on criteria 1 and 2, or 1 and 3 listed below:

1. Organic horizon thickness is greater than or equal to 10 cm. A horizon of less than 20 cm has 12 percent or more organic carbon when mixed to a depth of 20 cm.

2. Soils that are never saturated with water for more than a few days shall contain more than 20 percent organic carbon by weight (i.e., about 35 percent organic matter).

3. Soils are subject to water saturation episodes and have either:

    - At least 12 percent organic carbon by weight (i.e., about 20 percent organic matter) if the soils have no clay;
    - At least 18 percent organic carbon by weight (i.e., about 30 percent organic matter) if the soils have 60% or more clay; or
    - An intermediate proportional amount of organic carbon for intermediate amounts of clay.

Permanence

It's the capacity to maintain the carbon stocks pools for a long period beyond the project lifetime in the project areas. It can be influenced by a series of non-permanence risk factors that needs to be evaluated and generate a risk score, according with the Permanence Risk Analysis tool.

Project area

Area legally under control of the project owner or under control of the project holder with the necessary land tenure documents to proof the land propriety and meets all the eligible criteria. It is where REDD+ project activities will be implemented and where GHG emission reductions will be accounted for. More details in the section 13, of the BCR standard[9], v3.4.

[8] Hiraishi, Takahiko, et al. "2013 supplement to the 2006 IPCC guidelines for national greenhouse gas inventories: Wetlands." *IPCC, Switzerland* (2014).
[9] https://biocarbonstandard.com/wp-content/uploads/BCR_Standard.pdf

Project Start date

The start date is when the activities that result in effective GHG emission reductions begin. For REDD+ projects, the start date is when the activities proposed by the Project to demonstrate reduced emissions from deforestation and forest degradation begin. It may be, for example, the start of forest management strategies as also when applicable to forest resource conservation plans, including agreement and contracts. In other words, it shall be evidenced the exact date that had started the concrete actions to reduce deforestation/degradation.

REDD+

It is an international mitigation mechanism framed in the decisions of the UNFCCC, whose objective is to reduce emissions and remove GHGs through the implementation of activities to reduce emissions from deforestation, forest degradation, and other forestry activities.

REDD+ Project

These are GHG projects that implement activities aimed at reducing emissions due to deforestation and forest degradation, as well as promoting conservation, sustainable forest management and increasing forest carbon stocks.

REDD+ safeguards

Measures aimed at preventing the affectation of fundamental social, economic, or environmental rights and negative impacts due to the design and implementation of REDD+ activities. Likewise, it includes measures to improve the obtainment and distribution of benefits generated by REDD+ activities[10]. More details in the BCR tool for guaranteeing the necessary REDD+ projects Safeguards.[11]

Reference region

These are the geographic boundaries within which historical patterns of deforestation and forest degradation are analyzed and projected in the project area to obtain forest cover change values in the project area in the baseline scenario.

[10] Defined in the Cancun Agreement
[11] https://biocarbonstandard.com/wp-content/uploads/BCR_tool-safeguards-redd.pdf

Source, sink, or carbon pool-related

GHG sources, sinks and reservoirs identified and considered by the project holder. The project shall justify the inclusion or exclusion of any relevant GHG sources, sinks or reservoirs.

Underlying causes of deforestation

Underlying causes are factors that reinforce the direct causes of deforestation. They include social, political, economic, technological, and cultural variables, which constitute the initial conditions in the existing structural relationships between human and natural systems. These factors influence the decisions made by agents and help explain why deforestation occurs.

Unplanned deforestation

Unplanned deforestation is the result of activities associated with land use change that convert forest cover to non-forest cover, without making the legal process to request a deforestation permit under the applicable legal framework.

Wetlands

According the Ramsar Convention on Wetlands (Article 1)"wetlands are *areas of marsh, fen, peat, and or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters*." (Ramsar, 1971)[12].

IPCC defines wetlands as: "Wetlands include any land that is covered or saturated by water for all or part of the year, and that does not fall into the Forest Land, Cropland, or Grassland categories. Managed wetlands are restricted to wetlands where the water table is artificially changed (e.g., drained or raised) or those created through human activity"[13].

8 Carbon pools and sources of emissions

8.1 Carbon pools

The Intergovernmental Panel on Climate Change (IPCC) foresees the estimation of carbon stock changes in the following pools: aboveground biomass, belowground biomass, deadwood, litter, and soil organic carbon (SOC). The project holder may choose not to

[12] https://ramsar.org/documents?field_quick_search=2550
[13] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_07_Ch7_Wetlands.pdf

consider one or more carbon pools as long as they provide transparent and verifiable information of the conservative approach and need to demonstrate that the option does not impact an increase of emission reductions or removals GHG, quantified by the Project.

The selection of carbon pools to quantify changes in carbon stocks at the project boundaries are shown in Table 1.

Table 1. Carbon pools selected for the accounting of carbon stock changes

Carbon pool	Whether selected (Yes/No)	Justification/Explanation
Aboveground tree biomass vegetation	Yes	The change in carbon content in this pool is significant according to the IPCC.
Aboveground non-tree biomass vegetation	Optional	Mandatory if: 1. in the project scenario (after the change) stocks is lower than the baseline scenario and 2. when is significant[14].
Belowground tree biomass	Yes	The change in carbon content in this pool is significant according to the IPCC.
Belowground non-tree biomass	Optional	Not mandatory, the omission is conservative.
Deadwood	Optional	Excluding this carbon pool is a conservative approach; it is recommended to include it when it is deemed significant.[15]
Litter	Optional	Excluding this carbon pool is a conservative approach; it is recommended to include it when it is deemed significant.[16]
Soil organic carbon	Optional	The change in carbon stocks in this reservoir may increase due to project activities.

8.2 Source of emissions

The emission sources and associated GHGs selected for accounting are shown in Table 2.

Table 2. Emission sources and GHGs selected for accounting[17]

Source	GHG	Whether selected (Yes/No)	Justification/Explanation
	CO_2	No	CO2 emissions from biomass burning are considered as carbon stock change

[14] https://cdm.unfccc.int/EB/031/eb31_repan16.pdf
[15] https://cdm.unfccc.int/EB/031/eb31_repan16.pdf
[16] https://cdm.unfccc.int/EB/031/eb31_repan16.pdf
[17] These sources shall be considered, both in the baseline scenario and in the project scenario.

Source	GHG	Whether selected (Yes/No)	Justification/Explanation
Burning of woody biomass [18]	CH_4	Yes	It's conservative to exclude from the baseline scenario, shall be included in the monitoring period if the presence of fires was identified.
	N_2O	Yes	It's conservative to exclude from the baseline scenario, shall be included in the monitoring period if the presence of fires was identified.

9 Spatial and temporal limits

9.1 Project Areas

The project holder shall demonstrate that all project areas are eligible to a REDD+ project. The boundaries of the project area shall be clearly defined and included only forest category (as outlined by the national forest definition for the Clean Development Mechanism), which is defined as forest for minimum ten years before the project start date (defined as a stable forest) [19].

The project area will not change the boundaries after the project start date, if an unplanned change in the land use occurs in any of the monitoring period, the extension of the forest area will be reduced and this emission accounted as project emissions and reported in all the following monitoring reports. Also, a new category of land use will be reported as deforestation and actions to mitigate this impact will need to be presented by the project holder as an action plan to recover the vegetation of this specific area, more details in the risk analysis tool for non-permanence[20].

It's necessary to demonstrate that the project areas are under control of the project holder, presenting all the details of the landholder and related user rights to proof the land propriety and, consequently, the carbon rights.

9.1.1 Adding areas after validation

REDD+ project holders may add areas to the Project under the following conditions:

[18] The quantification of CH_4 and N_2O emissions caused by burning woody biomass is estimated based on the guidelines presented in the 2006 IPCC guidelines for national greenhouse gas inventories. Volume 4. Agriculture, forestry and other land uses. Non-CO_2 greenhouse gas emissions from biomass burning.
[19] The cartographic inputs for obtaining the stable and the detailed description of the methodological process for the generation of information on changes in forest area shall be based on credible information.
[20] https://biocarbonstandard.com/wp-content/uploads/BCR_risk-and-permanence.pdf

a) the project holder shall identify potential to the project expansion during the validation process and define in the Project Document the criteria for adding new areas;

b) the default criteria that a new area shall meet to be added to the REDD+ Project area:

    i) comply with the guidelines of the BCR Standard, in their most recent version;

    ii) comply with all the provisions in the Methodological document Quantification of GHG Emission Reductions from REDD+ Projects, in their most recent version;

    iii) include emission reduction only for validated REDD+ project activities[21].

    iv) implement the activities to avoid deforestation and forest degradation, described in the validated project document;

    v) the causes and agents of deforestation/degradation, the baseline scenario and the additionality conditions of new areas should be consistent with the characteristics of the initial areas validated;

    vi) It's located inside of the reference region previously validated;

    vii) have a start date later than the start date of the areas included in the validation.

c) Given that the validated leakage area may overlap with the new expansion area, the project holder shall update and validate the new leakage area to include potential deforestation displacements due to the implementation of REDD+ project activities and exclude the overlapped region.

9.2 Reference region for baseline estimation

The REDD+ project holder shall define a reference region to estimate the deforestation and forest degradation that could occur in the project area in the baseline scenario.

The reference region is defined by the geographic boundaries within which the historical patterns of deforestation and degradation are analyzed in the baseline scenario, which is projected to obtain the change values in the project area.

[21] An activity excluded in the validation cannot be contemplated in a new area. This does not refer to REDD+ activities (described in section 3 of this document) but to activities proposed by the project to avoid deforestation/degradation.

From this reference region, information is obtained on the causes and agents, as well as the historical trend of deforestation/degradation rates. Based on this information, the level of deforestation/degradation within the project boundaries should be projected.

The reference region shall be a plausible approximation of future deforestation patterns and shall be determined on the basis of evidence that it is a relevant geographic area for determining the baseline scenario of the project. The appropriateness of the reference region boundary shall be fully described in the project document.

The reference region shall be similar to the project area regarding access, drivers and determinants of deforestation/degradation and possible land use changes. The determination of the reference region boundaries shall be neutral. If the boundaries of the reference region include areas that meet the definition of forest, they should not be excluded from the reference region. Areas with high levels of deforestation should not be arbitrarily included in the reference region.

Additionally, to determine the geographic boundaries of the reference region is mandatory to consider the following criteria, justifying and giving all the evidences to the selected approach:

(a) the reference region shall include the project area;

(b) the reference region shall be bigger than the project area. The size of the reference region should be related to the mobility of deforestation agents that may have access to the project area, and the reference region is limited to 100 times the size of the project area[22];

(c) the reference region shall encompass all the required control plots area samples to attend the statistical thresholds from the similarity requirements. between the project boundaries;

(d) the project area shall be at least 90% similar in the following physical variables: annual precipitation, forest types, soils, slopes;

(e) the access roads density (m/km^2) shall not exceed more than 30% that the project area including a buffer around the project area of 2km, at the start of the reference period;

[22] Considering that a minimum number of representative control plots area must be included in the analysis, to represent the potential land use change in the project and leakage area.

(f) the reference region shall exclude any area formally designated for conversion or legally approved harvest (e.g., timber concessions, infrastructure corridors, agricultural expansion);

(g) socio-economic, cultural and land use conditions, as well applicable laws and policies related to legal status of the land, land use, land tenure, shall be similar to those in the project area and consistent with the reference region;

(h) any differences in land tenure or legal status between the project area and the reference region shall have no material effect on forest-loss dynamics; they must not influence the drivers, agents, or temporal trends of deforestation and degradation;

(i) the agents and drivers of deforestation/degradation expected to cause the deforestation/degradation in the baseline scenario (section 10.3) within the project area shall exist in the reference region; and can access the project area;

(j) special management areas[23] or areas within the geographic boundaries of other GHG projects shall be excluded from the reference region[24];

(k) the reference region shall exclude areas of restricted access[25] to agents and drivers of deforestation and forest degradation;

For items (h) and (i), if the project holder transparently demonstrates that the land use rights and management doesn't influence in this specific region the land use change, the reference region may include other types of lands, especially in situations of collective areas[26].

To perform this analysis the project holder shall use GIS and remote sensing tools to clearly demonstrate that different types of land tenure are affected by the same agents, drivers and causes of deforestation and degradation, the follow expected results to the reference period are: deforestation rates in different types of lands, total amount of deforestation in the

[23] Special Management Areas are geographic areas that contain a unique combination of physical and environmental characteristics that require special management techniques, or where the uniqueness of the area requires an even higher level of environmental protection.
[24] Under special conditions, however, where REDD+ projects may overlap, the relevance of including these areas of other GHG projects within the reference area should be justified.
[25] The project holder shall provide a spatial analysis demonstrating that the areas included in the reference region do not have any physical or administrative restrictions (e.g. slope, altitude, distance from access roads, protected areas, concessions, areas with high community control). This analysis shall consider the mobility of agents and the possibility of the deforestation driver to be mobile in these areas.
[26] Spatial units where land and natural-resource rights are held jointly by a defined group, rather than by individuals. The group enjoys secure and exclusive authority to own, manage and/or use the area under either customary or statutory tenure systems. Typical examples include Indigenous reserves, Afro-descendant collective territories, campesino community lands, ejidos, and community forest concessions.

different types of lands and index of similarity higher than 0.75 between the different types of lands.

9.3 Leakage area

The leakage area refers to the forest[27] surrounding or vicinity of the project area, where deforestation or forest degradation may occur as a consequence of project activities. This could mean any area where agents of deforestation or forest degradation are likely to be displaced due to project activities.

The leakage area shall be delimited based on the following criteria:

(a) all areas in the forest that are accessible to the project baseline deforestation agents identified in section 10 (below).[28]

(b) the leakage area is geographically distinct from the project area and control plot area, with no overlap;

(c) the leakage area excludes areas of restricted access to project baseline deforestation and forest degradation agents (see section 9.2, literal j), the project holder shall also exclude areas with different policies and laws applicable;

(d) the leakage area shall not overlap with other GHG project areas, see item (c) above;

(e) landscape aspects:

   (i) Forest types: shall be present in the leakage area with a minimum similarity of 50% from the project area;

   (ii) Soils types: shall be present in the leakage area with a minimum similarity of 50% from the project area;

   (iii) Slopes: shall be present in the leakage area with a minimum similarity of 50% from the project area.

(f) transportation aspects:

   (i) Access roads density (m/km^2): shall be present in the leakage area with a minimum similarity of 50% of the project area including a buffer around the project area of 2km, at the start of the reference period;

[27] The forest area shall meet the same eligibility criteria as the project area.

[28] The mobility distance of the agents can be determined from secondary studies or from the collection of primary information (participatory rural appraisal).

(ii) Navigable rivers density (m/km²): shall be present in the leakage area with a minimum similarity of 50% of the project area including a buffer around the project area of 2km, at the start of the reference period;

(g) the leakage area size shall be between 20%-50% of the project area size.

9.4 Control plots

Deforestation can be affected by a number of factors that change over time, so, ex post analyses (i.e., based on actual results rather than projected) using control plots (i.e., similar areas that were not exposed to REDD+ activities) is fundamental to create credible counterfactuals and estimating the real impact of REDD+ projects[29]. All the processes to identify the best clusters of control plots are based on GIS and remote sensing tools.

Control plots areas shall have the same characteristics of the project areas, so accessible to the same deforestation agent's groups described in the project baseline. Also, the control plots areas shall have similar landscape characteristics compared with the project area and be submitted to the same deforestation methods as expected in the project baseline scenario. The control plots areas shall be located inside of the reference region and is a pool or cluster of lands similar to the REDD+ project areas.

Characteristics to define a control plot area:

(a) Each control plot area size shall be between 90%-100% of the project area size.

(b) Accessibility:

(i) Access roads density (m/km²): shall be present in the control plots including a buffer around the control plots of 2km with a minimum similarity of 90% of the project area including a buffer around the project area of 2km, at the start of the reference period;

(ii) Navigable rivers density (m/km²): shall be present in the control plots including a buffer around the control plots of 2km with a minimum similarity of 90% of the project area including a buffer around the project area of 2km, at the start of the reference period.

(c) Biophysical characteristics:

[29] Haya, B. K., Alford-Jones, K., Anderegg, W. R. L., Beymer-Farris, B., Blanchard, L., Bomfim, B., Chin, D., Evans, S., Hogan, M., Holm, J. A., McAfee, K., So, I. S., West, T. A. P., & Withey, L. (2023, September 15). Quality assessment of REDD+ carbon credit projects. Berkeley Carbon Trading Project. https://gspp.berkeley.edu/research-and-impact/centers/cepp/projects/berkeley-carbon-trading-project/REDD+

(i) Forest types: shall be present in the control plot with a minimum similarity of 50% from the project area;

(ii) Soils types: shall be present in the control plot with a minimum similarity of 90% from the project area;

(iii) Slopes: shall be present in the control plot with a minimum similarity of 50% from the project area;

(d) Policies, laws and regulations: the control plots areas shall have the same applicable legislation of the project area (land use rights and management).

(e) The land use of the deforested areas inside the control plots areas shall be the same as the projected land use of the project deforestation baseline scenario.

The control plots areas will be used to estimate an average proportion of land that is cleared each year during the reference period, so a sufficient number of parcels are needed to be representative of the common practice in the control plot area, and thus also in the project area. To calculate the necessary number of plots the project holder shall analyze the deforestation trend in the reference period within the control plots, when the sample meets the statistical requirements ($p<0.05$ and $R^2>0.75$).

9.5 Temporal limits and analysis period

The project's temporal limits correspond to the periods during which project activities avoid land-use changes, the deforestation and/or degradation and which the GHG emission reductions are quantified.

The temporal limits of the Project should be defined considering the following:

(a) the project start date: the date that starts the project activities and/or is signed a commitment to implement the necessary activities to support the forest conservation of the project area.

(b) Historical reference period: The methodology suggestion of the reference period starts date of six years before the project start date to guarantee that the same dynamic of the land use change identified in the past is still active. The end date of the reference period shall be the closest data of the project start date.

If the project holder intends to use a large historical reference period (maximum of 10 years) it shall be justified and shall be a conservative selection of the most adequate period. So, the lowest deforestation historical rate inside of the control plots will define the adjustable reference period.

(c) the quantification period of the GHG reductions: The crediting period of the project shall be aligned with the BCR standard, version 3.4. or newest version.

(d) the monitoring periods: the minimum period is one year, and the maximum duration is the baseline period.

(e) Baseline period: The methodology suggests that the length of the validate baseline scenario projected in the first six years project implementation, shall be reassessed each six years.

10 Baseline scenario and additionality

10.1 Identification of the baseline scenario and additionality

To identify the most plausible baseline scenario and demonstrate additionality, the project holder shall follow the guidance provided in BCR's "Baseline and Additionality Guidelines"[30] in the most recent version.

Projects that are implemented within a Jurisdictional Nested REDD+ (JNR) region are eligible to use this methodology for activities included under that program. However, projects shall be nested according to the requirements set out in the BCR standard and specific tools that are under development by the standard.

Also, these same REDD projects shall follow the relevant jurisdictional program's requirements (baseline), but they shall be registered under BCR following this methodology. The project holder shall issue only the number of VCCs that would be issued based on the lower baseline, for example if the baseline computed using the activity data allocated to the project using this methodology is higher than the baseline set by the local government, the project holder must select the jurisdictional baseline. Such a restriction is essential where local laws demand it.

10.2 Activity data

10.2.1 Deforestation

Change in forest cover (CCF) provides the activity data for estimating deforestation. The first step is to quantify deforestation using a time-function approach: baseline deforestation rates are derived from historical CCF data in the project's control plots and projected with a statistically significant linear regression on time ($p \leq 0.05$; $R^2 \geq 0.75$). To

[30] https://biocarbonstandard.com/en/baseline-and-additionality-tool/

avoid bias, the project proponent must show—transparently—that model selection was conservative by applying a jackknife analysis and choosing the regression with the lowest residual error. Under this methodology, deforestation activity is therefore analyzed with a time-function linear model, and the resulting baseline is reassessed every six years.

10.2.2 Land use and Land cover temporal analysis

The project holder shall perform the land use, land cover analysis and transitions/permanence between at least two dates (start date and six years prior to the start date) [31].

It is required of the project holder to create a Standard Operation Procedure (SOP) document as annex to disclose all steps performed to estimate the historical rate of deforestation. This document will establish all requirements to be used in the project document and monitoring plan:

(a) collect the appropriate remote sensing data;

(b) methods employed in the remote sensing analysis (pre-processing, interpretation/classification and post-processing);

(c) accuracy analysis: a validation process of all the land use maps used in this section with statistical analysis and index with an acceptable error of 10% of the classification between the ground-truth and the image classified.

Only forest areas detected on the first date of the reference period and identified as no forest on the second date are considered as deforestation areas between two dates, so there is a certainty that the event occurred in the period analyzed (gross deforestation).

Areas that were not possible to be mapped in the start and end date of the reference period (i.e. clouds and shadows) shall be excluded from the reference region and, consequently, from the project area, control plots and leakage areas.

10.2.3 Historical period of deforestation

The analysis of the historical rate of deforestation for the reference region and control plots should be conducted at least two times (project start date and six years before the project starts date).

[31] Always using the cartographic inputs adequate and credible.

The deforestation trends observed historically, in the reference region and in the control plots areas should be similar. To demonstrate this similarity, the project holder shall perform the relevant statistical tests, disclosing all assumptions, calculus and results.

The analysis of the historical rate of forest degradation for the reference region and the control plots areas should be performed for at least two periods: project start date and six years before the project start date During each verification period, it is the responsibility of the project holder to demonstrate that the baseline corresponds to the baseline identified during project validation especially in the control plots areas, showing statically the error from the project deforestation and actual deforestation, and if this error is significantly (error>20%), it's necessary to update the geographic information and, consequently, the deforestation project baseline.

10.2.4 Reassessment of the baseline

Baseline projections for deforestation and/or degradation, and/or land use changes beyond a 10-year period are unrealistic. This is because there are numerous factors that affect land use change rates, and therefore it is difficult to predict these over the long term. As a result, it is important to conduct periodic reassessments of the baseline.

Consequently, the project holder shall, during the project duration, re-evaluate the baseline scenario in a maximum period of 6 years and submit it for validation with subsequent verification.

In each verification period, it is the responsibility of the project holder to demonstrate that the baseline corresponds to the baseline identified during project validation especially in the control plots areas, showing statically the error from the project deforestation and actual deforestation, and if this error is significantly (error>20%), it's necessary to update the geographic information and, consequently, the deforestation project baseline which will need to be validate again.

For purposes of conducting a baseline reassessment:

(a) the reassessment should consider changes in the drivers and/or behavior of the agents causing the land use changes, as well as all parameters used to estimate the baseline scenario;

(b) Adjust and update the carbon stocks of the selected pools if it's necessary;

(c) the results of the above items (1 and 2) shall be considered for adjusted/updated estimates of land use change, patterns of change and baseline scenario estimates;

(d) the latest approved version of the methodology or its replacement shall be in use at the time of the baseline reassessment;

(e) the project document shall be updated at the time of the baseline reassessment to reflect current requirements and the current version of the BCR Standard.

10.3 Analysis of causes, agents and drivers of deforestation and forest degradation

The project holder shall identify, describe and analyze the causes, drivers and agents of deforestation and forest degradation in the reference region, control plots areas and in the project area as input for:

(a) design measures and actions to avoid deforestation and forest degradation (REDD+ activities) in the project area and in the leakage area; and,

(b) support the delimitation of the reference region, section 9.2.

The following is a description of the key elements to develop a characterization of deforestation's causes, agents and drivers, as suggested by UN-REDD Program[32].

10.3.1 Spatial and temporal dimensions

Deforestation and forest degradation have spatial and temporal dimensions that need to be characterized. The spatial dimension helps to know and analyze the process's location and extent (project area, proposed reference region and control plots area). The temporal dimension allows understanding deforestation and forest degradation in terms of its historical antecedents (historical period of deforestation and forest degradation)., current dynamics, and potential future behavior of the agents and drivers of deforestation.

10.3.2 Context

After the baseline scenario was established, it shall be performed a detailed description of the agents, causes and drivers of deforestation. The correct understating of the deforestation agents is fundamental to reduce the activity shifting displacement risk due to the implementation of the project activities and to establish actions to mitigate the leakage risk.

Some aspects that may be analyzed in an initial approach to identify the agents, causes and drivers of deforestation:

[32] The present methodology accepts the use of the Minimum Characterization Scenario (MCS).

(a) The *territorial context* refers to the biophysical environment and how the agents use the land and are involved in the land change. It includes elements such as occupation, land use, social interaction, legal and regulatory aspects that govern these dynamics.

(b) The *sociocultural context* is based on the relationships between agents and how different agent's groups interact and organize themselves to live, use the natural resources and establish production in the reference region, municipalities and communities.

(c) The *economic context* refers to using the means of production to generate and trade goods and services, which contributes to the gross domestic product of a region.

(d) The *historical context* conditions the other types of contexts described above, as it is based on the construction of the deforestation agents as a process that occurs and changes in time and space. A particular relevance are the processes of occupation and production in the territory by different human groups.

10.3.3 Key actors, interests, motivations and impact

The deforestation and forest degradation processes involve multiple actors that are known as. deforestation and degradation agents, some of them indirectly promote forest change processes.

It is essential to characterize the interests or motivations that determine their decisions and their relationships with other key actors. In this sense, it is necessary to include in the analysis the underlying causes of deforestation and forest degradation identified for the project area, pointing out their importance within the group of factors that motivate agents to deforest and/or degrade.

Each key actor involved in the dynamics of deforestation and forest degradation has a degree of responsibility and influence and a geographic expression that shall be characterized and related to the phenomenon of deforestation and/or forest degradation.

Each cause, agent and driver have a differential impact on forests. The impact can be assessed qualitatively or quantitatively. Quantitative estimation of impacts can be made using a spatial analysis that determines the relationship between the identified cause and the calculated deforestation or forest degradation. Qualitative estimations can be made through the use of stakeholder participation in the territory through Participatory Rapid Diagnosis (PRA) methodology.

Some aspects shall be identified from the deforestation agents by the project holder in the reference area, project area, control plots area and leakage area.:

(a) name of the agent or agent group;

(b) historical, cultural, economic and territorial description of each agent or agent group;

(c) Analysis of the agent or agent group population size;

(d) Historical deforestation that can be attributable to each agent or agent group.

10.3.4 Economic activities and their importance (deforestation drivers)

Activities that directly cause deforestation and/or degradation should be characterized in terms of the spatial patterns associated with their presence, but also in terms of their economic and socio-cultural importance for the agents of deforestation or degradation and other key stakeholders involved. It is clear that activities with a high level of socio-cultural practices require different measures and actions than those where economic benefit prevails over other interests.

For the deforestation and degradation agents some factors affected their decisions and mainly two different types of variables drivers can be identified:

(a) related to the deforestation quantity: prices and costs of the products, population density and wages.

(b) related with the deforestation location: access to the forests; slope; proximity of markets, proximity to settlements/cities, landscape factors (agricultural fitness) and land management (conservation units, indigenous lands, etc.).

List all the deforestation drivers identified, briefly describing how each decision of the agent or agent group is affected by the driver's variables. Also, describe the likely future of the driver variable and the project activities that will be implemented to reduce the driver deforestation risk.

10.4 Confirm the causes of the Deforestation and forest degradation dynamic

The analysis of causes and dynamics seeks to identify the relationships between major groups of agents and causes to try to explain the sequence of events that usually leads to the loss of forest and forest degradation in a particular area. The agents' characteristics and decisions are themselves determined by broader forces

The project holder shall identify and link the underlying causes of the deforestation and/or degradation for each deforestation driver and respective agent, previously identified, that were involved directly or indirectly in the causes of the deforestation and degradation. For each cause identified the project holder shall describe the activities that will be implemented to mitigate this risk.

A useful tool for identifying, measuring and monitoring project drivers, causes, agents and activities is the Theory of Change (TOC). By using this theory as the guiding framework for project development, a logical and coherent structure is established to clearly identify the steps required to achieve deforestation and degradation reduction targets.

The TOC approach can be summarized by 1. define the problem; 2. identify the desired outcomes; 3. map the causal pathways; 4. transparently shows the assumptions made; 5. develop a visual representation and 6. validate and refine.

In a logical sequence, this framework represents the conditions and factors necessary to achieve impact and mitigation outcomes. Impacts and outcomes can be quantified in the short-term using variables that adequately describe the links between project activities and emission reductions.

A guide such as Conservation International's 'Constructing theories of change for ecosystem-based adaptation projects'[33] can be used to guide the GHG project holder. This guide provides a step-by-step approach to setting goals and objectives and understanding the relationships between different elements on the basis of a theory of change.

11 REDD+ activities

The project holder needs to identify and analyze the interactions and synergies between all elements and actors to define the REDD+ activities, it should be designed based on the results of causes and agents of deforestation and forest degradation analysis. Likewise, they shall consider what has been established by the communities, e.g., in the community life plans (in indigenous territories) and ethno-development plans (in afro communities). In the case of other rural communities, based on participatory construction.

The project holder shall implement activities to mitigate the potential displacement of the deforestation agents to other areas to avoid the leakage emissions, the leakage

[33] The Betty and Gordon Moore Center for Ecosystems, Science and Economics Conservation International. Constructing theories of change for ecosystem-based adaptation projects. A guidance document. Available at: https://www.conservation.org/docs/default-source/publication-pdfs/constructing-theories-of-change-for-ecosystem-based-adaptation.pdf?Status=Master&sfvrsn=1fd83348_3

management activities shall be implemented in areas where the deforestation agents are located, to engage them in the project objectives. Such activities may be related to technical assistance and rural extension to enhance the production in open areas and generate extra income to the population benefited by the project or others. The project holder should define a leakage management area to focus the implementation of the activities according to social vulnerability criteria of the communities located inside or in the project area neighborhoods.

One of the most recommendable tool to support the project activities design is the Participatory Rural Appraisal (PRA), the use of this method helps to make a diagnosis of the community that aims to be involved, alongside this process the project holder starts the communication of the REDD+ project, the benefits, risks and explain all details of the commitment with the project, in the end of this process the project holder, if it's necessary, shall conduct a Free Prior Informed Consent (FPIC[34]) process.

Alongside the process of design, the project activities to the local communities the project holder shall consider in all steps implemented the BCR Safeguards[35] tool and it's necessary to demonstrate the project conformance with all the requirements and rules established in the document.

The design of each REDD+ activity shall include, at a minimum, the following:

(a) activity ID;

(b) relationship between activity and direct or underlying cause;

(c) compliance with life plans or ethno-development plans or the interests of rural communities;

(d) consultation mechanism for objectives identification and the definition of REDD+ activities;

(e) responsibility and role of the actors involved in the implementation of the activity;

(f) implementation schedule;

[34] UN-REDD Programme Guidelines for Seeking the Free, Prior, and Informed Consent of Indigenous Peoples and other Forest Dependent

[35] https://biocarbonstandard.com/wp-content/uploads/BCR_tool-safeguards-redd.pdf

(g) indicators to report the activity's progress, including name, type[36], goal[37], measurement unit, and responsible for measurement.

The project holder shall describe each project activity (including the technologies) and the expected outputs, outcomes and impacts of the activities identifying the causal relationships, using the TOC approach, explain how the activities will contribute for the project and generate, consequently, the benefits to the climate, community and biodiversity benefits. It's necessary to describe the implementation timeline of project activity or activities.

Monitoring indicators shall be directly linked to the project objectives and activities and shall be specific, measurable, achievable, relevant and time-bound. For the construction of indicators, the project holder can refer to the EU manual and its annex[38]. The handbook "*aims to provide decision-makers with a comprehensive NBS impact assessment framework, and a robust set of indicators and methodologies to assess impacts of nature-based solutions across 12 societal challenge areas*". [39]

This methodology requires from the project holder the use of the BCR SDG tool[40] to verify the impacts of the project activities implementation in the sustainability agenda, specifically in the SDGs goals, benefits and safeguards.

12 GHG emission reduction from REDD+ activities

The project emissions reduction corresponds to the Project's quantification period, that is, the period during which the project holder quantifies the GHG emissions reductions or removals, measured against the baseline, to apply to the certification program issuance of Verified Carbon Credits (VCC). The analysis period for each verification corresponds to the monitoring period.

[36] Result, product, or impact
[37] Expected value and time for compliance
[38] European Commission, Directorate-General for Research and Innovation, (2021). Evaluating the impact of nature-based solutions: a handbook for practitioners, Publications Office of the European Union. https://data.europa.eu/doi/10.2777/244577
[39] European Commission, Directorate-General for Research and Innovation, Dumitru, A., Wendling, L., Evaluating the impact of nature-based solutions – Appendix of methods, Dumitru, A.(editor), Wendling, L.(editor), Publications Office of the European Union, 2021, https://data.europa.eu/doi/10.2777/11361
[40] https://biocarbonstandard.com/wp-content/uploads/BCR_SDG-Tool.xlsx

12.1 Uncertainty management

According to GOFC-GOLD (2016)[41]uncertainty i*s a property of a parameter estimate and reflects the degree of lack of knowledge of the true parameter value because of factors such as bias, random error, quality and quantity of data, state of knowledge of the analyst, and knowledge of underlying processes. Uncertainty can be expressed as a percentage confidence interval relative to the mean value. For example, if the area of forest land converted to cropland (mean value) is 100 ha, with a 95% confidence interval ranging from 90 to 110 ha, we can say that the area estimate's uncertainty is ±10%.*[42]

Under the BCR STANDARD, uncertainty management is determined by the accuracy of the maps used to estimate activity data values and the application of discounts in emission factors. For activity data, the accuracy should be greater than 90%. The accuracy assessment, for example, to the elaboration of land use maps should be made from the use of field observations or analysis of high-resolution imagery (10 m, Sentinel), if the project holder uses this information from other sources, it's necessary to report the uncertainty analysis process made by secondary databases or third parties.

For emission factors, an uncertainty of less than 10% is acceptable for the use of average carbon values (assessment should be done per repository). Uncertainty assessment

According to IPCC, an assessment of uncertainty requires that uncertainty in per area emission/removal rates as well as uncertainty in the activity data (i.e. the land areas involved in land-use and management changes), and their interaction be estimated. [43]

The mitigation results associated with the reduction of greenhouse gas (GHG) emissions from avoided deforestation and/or degradation are equal to the sum of the products of the emission factors and the activity data. However, where different uncertainty values associated with the emission factor are available, they can be combined to provide accurate uncertainty estimates. The IPCC provides two convenient methods for combining uncorrelated uncertainties: addition and multiplication. [44]

[41] GOFC-GOLD, 2016, A sourcebook of methods and procedures for monitoring and reporting anthropogenic greenhouse gas emissions and removals associated with deforestation, gains and losses of carbon stocks in forests remaining forests, and forestation. GOFC-GOLD Report version COP22-1, (GOFC-GOLD Land Cover Project Office, Wageningen University, The Netherlands). Available at: http://www.gofcgold.wur.nl/redd/sourcebook/GOFC-GOLD_Sourcebook.pdf.
[42] The project holder should describe how it addressed the GOFC-GOLD (2016) guidelines in estimating uncertainty.
[43] IPCC Good Practice Guidance for LULUCF, https://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf/english/ch3.pdf
[44] IPCC Quantifying Uncertainties in Practice, https://www.ipcc.ch/site/assets/uploads/2018/03/6_Uncertainty-1.pdf

12.1.1 Rule A

Where uncertain quantities are to be combined by addition, the standard deviation of the sum will be the square root of the sum of the squares of the standard deviations of the quantities that are added with the standard deviations all expressed in absolute terms (this rule is exact for uncorrelated variables).

Using this interpretation, a simple equation can be derived for the uncertainty of the sum, that when expressed in percentage terms becomes:

$$U_{total} = \frac{\sqrt{(U_1 \cdot x_1)^2 + (U_2 \cdot x_2)^2 + \cdots + (U_n \cdot x_n)^2}}{x_1 + x_2 + \cdots x_n} \quad (1)$$

Where:

U_{total}	the percentage uncertainty in the sum of the quantities (half the 95% confidence interval divided by the total (i.e. mean) and expressed as a percentage);
x_1	uncertain quantities
U_i	percentage uncertainties associated with them,

12.1.2 Rule B

Where uncertain quantities are to be combined by multiplication, the same rule applies except that the standard deviations shall all be expressed as fractions of the appropriate mean values (this rule is approximate for all random variables).

A simple equation can also be derived for the uncertainty of the product, expressed in percentage terms:

$$U_{total} = \sqrt{(U_1)^2 + (U_2)^2 + \cdots + (U_n)^2} \quad (2)$$

Where:

U_{total}	is the percentage uncertainty in the product of the quantities (half the 95% confidence interval divided by the total and expressed as a percentage);
U_i	the percentage uncertainties associated with each of the quantities

Rules A and B can be used repeatedly to estimate the uncertainty of mitigation results. However, the guidance provided by the IPCC does not exclude the use of better methods as they become available.

If the data and parameters used to calculate GHG emission reductions are consistent with the emission factors, activity data, GHG emission projection variables, and other parameters used to construct the national GHG inventory, the uncertainty associated with the inventory data should be applied.

If the cumulative total uncertainty (U_{total}) of the baseline and project scenario parameters (land use maps, carbon pools, and others) used to the calculation of the GHG emission reduction is less than 15%, a discount factor of the same amount of the U_{total} shall be applied to the total Verified Carbon Credits; if the U_{total} exceeds 15% a default value of 15% shall be applied to the VCC; if the U_{total} exceeds 20% the project holder will need to collect new detailed data to enhance the project accuracy and avoid bias to the project calculation.

12.1. Deforestation baseline scenario calculation

12.1.3 Historical annual deforestation in the reference region

The calculation of the deforestation rate in the reference region is based on overextending the deforestation historical evolution as a function of time using a simple linear regression model.

The model and its parameters are derived from data obtained from the historical reference period and are used to project future deforestation. The following equation estimates annual historical deforestation in the reference region:

$$BAA_{RR,t,i} = a + b * t \tag{3}$$

Where:

$BAA_{RR,t,i}$	Baseline annual area of deforestation within the reference region at year t; at vegetation type i, ha
t	1,2, 3 ...T year of the baseline annual deforestation projection
i	1,2,3... N number of vegetation types
a	indicates the point of intersection of the function with the y-axis (t in years) in the Cartesian plane
b	indicates whether the function is ascending or descending and the respective slope,

Where the linear regression model does not fit in the statistical requirements ($p<0.05$ and $R^2>0.75$), the historical average between the first date of the reference period and the last date of the reference period shall be used instead to all the reference region.

12.1.4 Historical annual deforestation in the control plots area (baseline scenario)

The calculation of the deforestation rate in the control plots area is based on overextending the deforestation historical evolution as a function of time using a simple linear regression model.

The model and its parameters are derived from data obtained from the historical reference period and are used to project future deforestation. The following equation estimates annual historical deforestation in the control plot area:

$$BAA_{CP,t,i} = a + b * t \tag{4}$$

Where:

$BAA_{CP,t,i}$=	Baseline Annual Area of deforestation within the control plot area at year t; at vegetation type i, ha
t =	1,2, 3, ... T year of the baseline annual deforestation projection
i =	1,2,3... N number of vegetation types
a =	indicates the point of intersection of the function with the y-axis in the Cartesian plane
b =	indicates whether the function is ascending or descending and the respective slope;

Where the linear regression model does not fit in the statistical requirements ($p<0.05$ and $R^2>0.75$) the historical average between the first date of the reference period and the last date of the reference period shall be used instead to the control plots area.

The project holder shall analyze the similarity between the deforestation rate in the reference region and in the control plots area using similarity indexes to assess the degree of similarity between the reference region and the control plots area. The project holder shall use Geographic Similarity Analysis (GSA) or a similar analysis, it's necessary to report all the steps established in this analysis and the final result shall be superior to an 80% similarity between the control plot area and the reference region.

In each monitoring event and respective verification process the project holder shall assess the baseline accuracy in the control plots area and if the error of the real deforestation compared with the projected deforestation exceeds 20% the baseline deforestation will need to be updated and validated again during the audit process.

12.1.5 Historical annual deforestation in the project area

The estimation of the annual historical deforestation in the baseline scenario within the project area is estimated by applying the equation:

$$FSC_{A,BL,i,t} = \left(\frac{BAA_{CP,t,i}}{A_{CP,i}}\right) x\ (A_{At,i}) \tag{5}$$

Where:

$FSC_{A,BL,i,t} =$	Annual change in the surface covered by forest in the project area during the baseline scenario; at year t; at vegetation type i, ha
$BAA_{CP,t,i}$=	Baseline Annual Area of deforestation within the control plot area, at year t; at vegetation type i, ha
$A_{CP.i} =$	Forest surface in all control plots area in the initial moment; at vegetation type i, ha
$A_{At,i} =$	Forest Surface in the Project area[45], in the t moment; at vegetation type i, ha
$i =$	1,2,3...N, number of vegetation types
$t =$	1,2,3 ... T ($dimensionless$)

The proportion between the Baseline Annual Area (BAA) and the forest surface in all control plots area in the initial moment corresponds to the historical deforestation rate of the control plots area in the reference period and this value is used to project the expected forest loss in the project area during the validated baseline scenario.

12.1.6 Annual deforestation in the REDD+ project scenario (ex-ante scenario)

The projected annual deforestation in the REDD+ Project scenario is estimated with the equation:

[45] t corresponds to the year in which the coverage is evaluated, so each area is different in each year.

$$FSC_{REDD+project,i,t} = FSC_{A,BL,i,t} \, x \, (1 - \%DD) \quad (6)$$

Where:

$FSC_{REDD+project,t,i}$	=	Annual change in the surface covered by forest in the project scenario; at vegetation type i, ha
$FSC_{A,BL,t,i}$	=	Annual change in the surface covered by forest in the project area; at vegetation type i, ha
%DD	=	Projected decrease in deforestation due to the implementation of REDD+ activities
i	=	1,2,3… N, number of vegetation types
t	=	$1,2,3 \ldots T \ (dimensionless)$

The projection of the reduction in deforestation resulting from the implementation of REDD+ activities should indeed be based on a comprehensive analysis of the potential project's effectiveness. This includes a detailed description of how the activities and implementation of the project will contribute to the reduction in deforestation over time and the assumption of the project effectiveness.

12.1.7 Annual historical deforestation in the leakage area

The estimation of the annual historical deforestation in the baseline scenario within the leakage area is estimated by applying the equation:

$$FSC_{LK,BL,i,t} = \left(\frac{BAA_{CP,t,i}}{A_{CP,i}}\right) x \, (A_{LKi,t,i}) \quad (7)$$

Where:

$FSC_{LK,BL,i,t}$	Annual change in the surface covered by forest in the leakage area; at vegetation type i, ha.
$BAA_{CP,i,t}$=	Baseline Annual Area of deforestation within the control plot area at year t; at vegetation type i, ha.
$A_{CP,i}$ =	Forest surface in all the control plots area in the reference region, at vegetation type i, in the initial moment; ha.

$A_{lk,i,t} =$	Forest Surface in the leakage area[46], in the t moment; at vegetation type i, ha
$i =$	1,2,3... N, number of vegetation types
$t =$	$1,2,3 \ldots T\ (dimensionless)$

The proportion between the Baseline Annual Area (BAA) and the forest surface in all control plots area in the initial moment corresponds to the historical deforestation rate of the control plots area in the reference period and this value is used to project the expected forest loss in the leakage area during the validated baseline scenario.

12.1.1. Projected annual deforestation in the leakage area in the project scenario (ex-ante scenario)

The projected annual deforestation in the leakage area in the project REDD+ scenario is estimated with the equation:

$$FSC_{REDD+project,LK,i,t} = FSC_{LK,BL,i,t}\ x\ (1 + \%E_{lk}) \quad (8)$$

Where:

$FSC_{REDD+project,LK,t,i}$	Annual change in the surface covered by forest in leakage area in the project scenario; at vegetation type i, ha
$FSC_{LK,BL,t} =$	Annual change in the surface covered by forest in leakage area in the baseline scenario; at vegetation type i, ha
$\%E_{lk}$ =	Percentage of expected emissions increase in the leakage area due to the implementation of REDD+ activities. The use of a cap default value of 10% is allowed in this Methodology[47]
$i =$	1,2,3...N, number of vegetation types
$t =$	$1,2,3 \ldots T\ (dimensionless)$

[46] t corresponds to the year in which the coverage is evaluated, so each area is different in each year.
[47] Despite this default value, it is considered good practice for this percentage to be defined by the project holder based on the performance of the project activities related to leakage management in other similar projects located preferably inside the reference region.

12.2 Degradation baseline scenario calculation

Forest degradation can be defined as a direct human-induced loss of forest values (particularly carbon), likely to be characterized by a reduction of tree crown cover. The estimation of this impact shall be calculated through variables that can be measurable in areas where the extension, canopy cover, and minimum height remain above the forest definition thresholds. The net greenhouse gas emissions resulting from degradation is the sum of stock changes due to degradation through extraction of trees for illegal timber or fuelwood and charcoal, and extraction of trees for selective logging from forest management areas

In this methodology, the forest degradation shall be included in the baseline scenario only if the forest cover inside of the project area had suffered any degradation activities[48] (such as Forestry Management, fires or illegal timber for multiple purposes) in the reference period. The project holder needs to give all the evidence that the project area had degradation activities (remote sensing analysis, documents of the forestry management and others) during the baseline period. For monitoring purposes, the degradation shall be always considered in the project and leakage areas.

To define the forest degradation activity data, the project holder shall apply an adequate methodology to identify and map the degraded forest in an accuracy necessary during the reference period inside of the project area (preferably) and/or in the control plots area. For consistency purposes, it is mandatory that the same methods employed to analyze the degradation dynamic in the reference period will be applied to the monitoring period. Additionally in the monitoring period it is recommended to the project holder to enhance the quality of the information, and the Lidar cameras are useful to support the identification of the total forest degraded area.

Approaches like remote sensing with ground truthing, forest/vegetation sampling, activity reporting, or a combination of these techniques can be used to identify land areas affected by processes leading to deforestation and forest degradation. High-resolution remote sensing with continuous spatial coverage, greater intensity sampling systems, or thorough and detailed activity reporting systems may be necessary for low or small thresholds. The NDFI[49] methodology or similar is recommended to this analysis, the NDFI is more sensitive to canopy damage than any individual fraction and is shown to have the potential for further sub-classification of degradation levels in forest environments. For estimate the

[48]Grazing activities will be included in the land use improvement methodology which is under development and might be release in 2026.

[49] Souza Jr., C., Roberts, D. A. and Cochrane, M. A. 2005a. Combining spectral and spatial information to map canopy damage from selective logging and forest fires. Remote Sensing of Environment. 98 329-343p. Doi: 10.1016/j.rse.2005.07.013

burned areas one approach that the project holder can uses is the NBR[50]. Remote sensing degradation analysis shall follow these steps:

(a) Pre-Processing: Type, resolution, source and acquisition date of the remotely sensed data (and other data) used; geometric, radiometric and other corrections performed, if any; spectral bands and indexes used (such as NDFI); projection and parameters used to geo-reference the images; error estimate of the geometric correction; software and software version used to perform tasks; etc.

(b) Construction of a Spectral Library: Definition of the classes and categories; classification approach and classification algorithms; coordinates and description of the ground-truth data collected for training purposes;

(c) Spectral Mixture Modeling (MME): Ancillary data used in the classification, if any; software and software version used to perform the classification; additional spatial data and analysis used for post-classification analysis, including class subdivisions using non-spectral criteria, if any; etc.

(d) Automatic Classification;

(e) Post-Classification: Accuracy assessment technique used; coordinates and description of the ground-truth data collected for classification accuracy assessment; and final classification accuracy assessment.

12.2.1 Historical annual forest degradation in the baseline scenario

The calculation of the degradation rate in the control plots area is based on overextending the degradation historical evolution as a function of time using a simple linear regression model.

The project holder shall estimate the forest degradation considering 3 potential scenarios (1. illegal extraction, 2. logging, 3. fires), each of them shall be calculated separately, considering different dynamics of the drivers of degradation. If inside of the project area is possible to collect information of the 3 potential scenarios, the analysis shall consider this data.

If the logging activities (scenario 2) don't exist in the reference period within the project area, this activity cannot be considered in the baseline scenario but shall be monitored. If

[50]https://un-spider.org/advisory-support/recommended-practices/recommended-practice-burn-severity/in-detail/normalized-burn-ratio

the logging activities exist in the project area, all the information of the wood extraction shall be based on the historical official documents from the reference period.

If the illegal extraction (scenario 1) and fires (scenario 3) doesn't exist in the reference period within the project area, it may be considered in the baseline scenario if it was identified and mapped these activities in the control plots area during the reference period and the degradation rates can be interpolated to the project area.

The model and its parameters are derived from data obtained from the historical reference period and are used to project future degradation. The following equation estimates annual historical degradation in the project area or in the control plot area:

$$BAA_{Deg,CP,s,t,i} = a + b * t \quad (9)$$

Where:

$BAA_{Deg,CP,t,i}$	Baseline Annual Area of degradation within the control plot area at year t; at vegetation type i, ha
t =	1,2, 3…T year of the baseline annual degradation projection
i =	1,2,3…N, number of vegetation types
a =	indicates the point of intersection of the function with the y-axis in the Cartesian plane
b =	indicates whether the function is ascending or descending and the respective slope;
s =	degradation scenario (1. illegal extraction, 2. logging, 3. fires)

Where the linear regression model does not fit in the statistical requirements ($p<0.05$ and $R2>0.75$) the historical average between the first date of the reference period and the last date of the reference period shall be used instead.

12.2.2 Project area baseline degradation scenario

$$FDeg_{A,BL,s,i,t} = \left(\frac{BAA_{Deg,CP,s,t,i}}{A_{CP,i}}\right) x\ (A_{A,i,t}) \quad (10)$$

Where:

$FDeg_{A,BL,s,i,t} =$	Annual degradation in the surface covered by forest in the project area during the baseline scenario; at vegetation type i, at year t, ha.
$BAA_{Deg,CP,i,t}$=	Baseline Annual Area of degradation within the control plot area at year t; at vegetation type i, ha.
$A_{CP,i} =$	Forest surface in all the control plots area; at vegetation type i, ha
$A_{A,t,i} =$	Forest Surface in the Project area, in the t moment; at vegetation type i, ha
$s =$	degradation scenario (1. illegal extraction, 2. logging, 3. fires)
$i =$	1,2,3… N, number of vegetation types
$t =$	$1,2,3 \ldots T\ (dimensionless)$

12.2.3 Leakage area baseline degradation scenario

$$FDeg_{LK,BL,s,i,t} = \left(\frac{BAA_{Deg,CP,t,i}}{A_{CP,i}}\right) x\ (A_{LK,i,t}) \tag{11}$$

Where:

$FDeg_{LK,BL,,i,s,t}$	Annual degradation in the surface covered by forest in the leakage area; at vegetation type i, ha.
$BAA_{Deg,CP,t}$	Baseline Annual Area of degradation within the control plot area at year t; at vegetation type i, ha.
$A_{CP,i} =$	Forest surface in all the control plots area in the reference region in the initial moment; at vegetation type i, ha.
$A_{lk,i,t} =$	Forest Surface in the leakage area, in the t moment; at vegetation type i, ha
$s =$	degradation scenario (1. illegal extraction, 2. logging, 3. fires)

The proportion between the Baseline Annual Area degraded (BAA) and the forest surface in all control plots area in the initial moment Forest annual degradation (F_{Deg}) corresponds to the historical deforestation rate of the control plots area in the reference period and this value is used to project the expected forest degradation in the leakage area during the validated baseline scenario, considering the degradation activities defined in scenario 1 and 3.

12.1.2. Annual projected forest degradation in the project area in the REDD+ project scenario (ex-ante)

The projected forest degradation in the project area in the project scenario is estimated with the following equations:

$$PFD_{REDD+projec,s,i,t} = FDeg_{A,BL,s,i,t} * (1 - \%PFD) \quad (12)$$

Where:

$PFD_{REDD+project,s,t} =$	Annual forest degradation in the project area, in project scenario; at year t, at vegetation type i, ha
$FDeg_{A,BL,s,t} =$	Annual degradation in the surface covered by forest in the project area during the baseline scenario; at year t, at vegetation type i, ha.
%PFD =	Projected decrease in primary forest degradation due to the implementation of REDD+ activities
s =	degradation scenario (1. illegal extraction, 2. logging, 3. fires)
$i =$	1,2,3…N, number of vegetation types
$t =$	$1,2,3 \ldots T$ $(dimensionless)$

12.2.4 Annual projected forest degradation in leakage area in the project scenario

The annual projected forest degradation in leakage area is estimated with the following equations:

$$PFD_{lk,s,i,t} = FDeg_{lk,BL,s,i,t} * (1 + \%E_{lk}) \quad (13)$$

Where:

$PFD_{lk,s,i,t} =$	Annual primary forest degradation in leakage area, in the project scenario; at year t, at vegetation type i, ha
$FDeg_{lk,BL,s,i,t} =$	Annual degradation in the surface covered by forest in the project area during the baseline scenario; at year t, at vegetation type i, ha.

$\%E_{lk}$=	Percentage of emissions increase in the leakage area due to the implementation of REDD+ activities. The use of a default value of 10% is allowed in this Methodology.
s =	degradation scenario (1. illegal extraction, 2. logging, 3. fires)
$i =$	1,2,3…N, number of vegetation types
$t =$	$1,2,3 \ldots T$ $(dimensionless)$

12.3 Estimation of the carbon stocks and carbon stock changes (emission factors)

The project holder may determine the carbon stocks and the respective emission factors using biomass data estimated from sampling plots in all vegetation strata with different carbon stocks inside the reference region, control plots area, project area and leakage area. The establishment of plots shall follow the sampling requirements described by the IPCC[51], including: (i) sampling principles, (ii) sampling design, (iii) sampling methods for area estimation, (iv) sampling methods for estimating emissions and removals of greenhouse gases, and (iv) uncertainties in sample-based surveys.

Ensuring that field data and samples are representative and independently collected is critical to obtaining accurate results. To increase the accuracy and validity of the results obtained from the sample's, sampling precision is required to be within (10%) of the true value of the mean at the 95% confidence level. This practice serves to minimize sampling error and assure the reliability of the data collected.

12.3.1 Pre-deforestation forest class aboveground tree biomass stocks

The project holder shall consider the 3 below aspects and shall report all the steps, approaches and assumptions as an SOP document of the forestry inventory.

(a) Calculate the tree dimensions of each tree above a minimum DBH in the sample plots, including diameter (DBH), which is normally 1.3 m [4.3 ft] above ground level or above buttresses where they occur, and total height H. The allometric equation chosen in Step 2 will define the precise tree dimensions and minimum size tree to be measured in sample plots. For the life of the project, all minimum values used in inventories remain unchanged.

(b) Choose or create a suitable and verified allometric equation for each species or family j (group of species) identified in the inventory (henceforth referred to as a species

[51] Good Practice Guidance for LULUCF (IPCC, 2003). https://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/Chp5/Chp5_3_Sampling.pdf

group) or for the forest type/group of species j (for example, tropical wet forest or tropical dry forest).

(c) Using the chosen or created allometric equation applied to the tree dimensions obtained from Step 1, estimate the carbon in aboveground biomass for each individual tree of species group j in the sample plot situated in stratum i. Then, add up the carbon stocks in all the sample plot, considering all the individuals (l) of all group species (j) in all strata (i):

$$ABG_{tree,i} = \sum_{j=1}^{S}\sum_{l=1}^{L} F(X, Y \dots)_{j,l} \qquad (14)$$

Where:

$ABG_{tree,i}$	=	Total biomass in the aboveground carbon pool,at vegetation type i,t d.m./sample plot area
$F(X, Y \dots)_{j,l}$	=	Aboveground biomass of trees based on the allometric equation,t d.m./tree
l	=	1,2,3…,L tree individuals
j	=	1,2,3…,S group of species
i	=	1,2,3…,N vegetation types

12.3.2 Pre-deforestation Forest class below ground tree biomass stocks

Determining each plot below ground tree biomass carbon stock through the allometric equation approach, it can be used to estimate the aboveground tree biomass carbon stored in each plot.

$$BLG_{tree,i} = ABG_{tree,i} \times R \qquad (15)$$

Where:

$BLG_{tree,i}$	=	Total biomass in the belowground carbon pool,at vegetation type i,t d.m./sample plot area
$ABG_{tree,i}$	=	Total biomass in the aboveground carbon pool,at vegetation type i,t d.m./sample plot area
R	=	root to shoot ratio,t root d.m./t shoot d.m.

i	=	1,2,3...,N vegetation types

12.3.3 Pre-deforestation Forest class above ground non-tree biomass stocks

Shrubs, bamboo, and other vegetation kinds where individuals may be easily identified and can be treated under this technique. All shrubs, trees smaller than the minimum tree size determined in the tree biomass pool, and any other non-herbaceous living vegetation are included in the non-tree woody aboveground biomass pool.

The project holder shall develop a protocol which considers the selection or development of an allometric equation and the estimation for each individual m in the sample plot r (can be smaller and shall be located inside of the above ground tree biomass sample plot). The protocol shall consider the same 3 steps defined in the section 12.3.1 (trees aboveground biomass).

$$ABG_{non-tree,i} = \sum_{j=1}^{S} \sum_{i=1}^{N} F(X, Y \ldots)_{j,l} \quad (16)$$

Where:

$ABG_{non-tree,i}$	=	Total biomass in the aboveground carbon pool,at vegetation type i,t d.m./sample plot area
$F(X, Y \ldots)_{j,l}$	=	Aboveground biomass of non-trees based on the allometric equation,t d.m./tree
l	=	1,2,3...,N non-tree individuals
j	=	1,2,3...,S group of species
i	=	1,2,3...,N vegetation types

12.3.4 Pre-deforestation forest class belowground non-tree biomass stocks

Determining each plot belowground non-tree biomass carbon stock through the allometric equation approach, it can be used to estimate the above-ground non-tree biomass carbon stores in each plot.

$$BLG_{non-tree,i} = ABG_{non-tree,i} \times R \quad (17)$$

Where:

$BLG_{non-tree,i}$	=	Total biomass in the belowground carbon pool, at vegetation type i,t d.m./sample plot area
$ABG_{non-tree,i}$	=	Total biomass in the aboveground carbon pool,at vegetation type i,t d.m./sample plot area
R	=	root to shoot ratio,t root d.m./t shoot d.m.
i	=	1,2,3…,N vegetation types

12.3.5 Pre-deforestation forest class dead wood biomass stocks

12.3.5.1 Standing dead wood

The same standards, such as the minimum Diameter at Breast Height (DBH) that are used to measure live trees shall also be applied to standing dead trees. It is necessary to inventory stumps as though they were short dead trees.

If a dead wood standing tree exhibits decomposition symptoms, such as the loss of twigs, branches, or the crown, in addition to the loss of leaves, the biomass stocks shall be estimated using an appropriate equation with a standard rate decay. More technical information and details can be found in the Winrock report[52].

12.3.5.2 Lying dead wood

The line intersect approach shall be used to sample lying dead wood (Harmon and Sexton 1996[53]).

According to Section 4.3.3.5.3 of the IPCC Good Practice Guidance for LULUCF (2003), the "machete test" is used to classify the dead wood into one of the three density categories (sound, intermediate, or rotten). According to the measured parameters section below, the dead wood density class (dc) is determined at the intersection with the sample line. For each density state, the equation proposed by Van Wagner (1968)[54] is used to estimate the volume of lying dead wood per unit area.

[52] AG Biomass Estimation Approaches
[53] Harmon, M.E. and J. Sexton. (1996) Guidelines for measurements of wood detritus in forest ecosystems. US LTER Publication No. 20. US LTER Network Office, University of Washington, Seattle, WA, USA.
[54] Van Wagner, C.E. (1968). The line intersect method in forest fuel sampling. Forest Science 14: 20-26.

12.3.6 Pre-deforestation forest class litter biomass stocks

The project holder needs to define the SOP to collect and analyze this carbon pool, the sample plot to collect the litter shall be located inside of the above ground measurement sample plot and the data of this pool shall be updated in the same moment of the other carbon reservoirs.

The SOP shall contain the characteristics of the data collector and the allocation in the collect moment shall be fixed (geographic information of the sample plot) during the project lifetime to allow the carbon pool remeasurement in the update of the carbon stocks reservoirs.

One protocol that may be applicable to the REDD+ project is the Litterfall Monitoring Protocol CTFS Global Forest Carbon Research Initiative[55] or any other which is published by a scientific known magazine and conservative in terms of the calculus of the carbon stocks of this pool.

12.3.7 Pre-deforestation forest class Soil Organic Carbon (SOC) biomass stocks

The following describes the steps to be taken when measuring soil organic carbon. The identical strata used for the other included pools will also be used for soil organic carbon.

The project holder needs to define the SOP to collect and analyze this carbon pool, the sample plot to collect the SOC information shall be located inside of the above ground measurement sample plot and the data of this pool shall be updated in the same moment of the other carbon reservoirs.

The SOP shall contain the characteristics of the data collector and the allocation in the collect moment shall be fixed (geographic information of the sample plot) during the project lifetime to allow the carbon pool remeasurement in the update of the carbon stocks reservoirs.

Some basic aspects that the SOP shall consider:

(a) Standardized Sampling: Guidelines outline the proper depth, frequency, and sampling techniques (such as stratified sampling and systematic sampling) for soil sample collection.

(b) Laboratory Analysis: To calculate the SOC content, standard laboratory procedures are employed, frequently involving the use of elemental analysis or wet oxidation.

[55] Litter_Protocol_20100317

(c) Long-term Monitoring: To track changes in SOC over time and evaluate the efficacy of forest management techniques, several protocols place a strong emphasis on long-term monitoring.

For the fact that exists different types of measures protocol, the project holder shall define a conservative one and that follows the IPCC guidelines[56] to quantify the carbon stocks in this reservoir.

12.3.8 Deforestation (post-deforestation classes)

The project holder shall determine the post-deforestation classes' long-term (20-year) average carbon stocks. Because diverse land uses may be implemented in a sequential manner or because land use following deforestation implies changes in carbon stocks over time (e.g., in tree plantations), these classes frequently lack stable carbon stores. Measurements in plots of known age, long-term research, or other credible sources can be used to estimate the carbon stock of post-deforestation classes, which shall be the long-term (20-year) average.

The estimation of the post deforestation carbon stocks can be performed using literature estimates where the precision and conservatism of the estimates are shown, carbon stock estimates in comparable ecosystems that are based on local studies, literature, and IPCC default values may be used. When using default values, the literature source's the upper value (which is 30% higher) for the non-forest classes shall be applied.

12.3.9 Deforestation forest biomass stock change

Total biomass (TB) is estimated from the sum of aboveground biomass (AB) and belowground biomass (BB). The carbon content of total biomass (CCB) is the TB product and the carbon fraction of dry matter (CF[57]). The carbon dioxide equivalent content in the total biomass (CO_{2eq}) is the product of CCB and the molecular ratio constant between carbon (C) and carbon dioxide (CO2). Then, the estimation of CO_{2eq} is done according to the equation:

$$TBi = (ABG_{tree,i} + BLG_{tree,i} + ABG_{non-tree,i} + BLG_{non-tree,i} + DWi + Li_i) \quad (18)$$

Where:

[56] IPCC GPG LULUCF
[57] Carbon fraction of the dry matter is 0,47, according to IPCC (2006)

TBi	=	Total biomass in carbon pools included,at vegetation type i,t d.m./ha
$ABG_{tree,i}$	=	Total biomass in the aboveground tree carbon pool,at vegetation type i,t d.m./ha
$BLG_{tree,i}$	=	Total biomass in the belowground tree carbon pool,at vegetation type i,t d.m./ha
$ABG_{non-tree,i}$	=	Total biomass in the aboveground non-tree carbon pool,at vegetation type i,t d.m./ha
$BLG_{non-tree,i}$	=	Total biomass in the belowground non-tree carbon pool,at vegetation type i,t d.m./ha
DWi	=	Total biomass in the dead wood carbon pool,at vegetation type i,t d.m./ha
Li_i	=	Total biomass in the litter carbon pool,at vegetation type i,t d.m./ha
i	=	1,2,3…,N vegetation types

According to the IPCC, it is assumed that all carbon contained in the aboveground and belowground biomass is emitted in the same year that the deforestation event occurs.

12.3.9.1 *Soil organic carbon emission factor*

To estimate emissions from deforestation of the soil, a gross emission is assumed where the soil organic carbon (SOC) is emitted in equal proportions considering a decay rate of 20 years once the deforestation event occurs.

12.3.9.2 *Total carbon emission factor*

The total carbon emission factor includes the carbon dioxide equivalent emission per hectare deforested, including the biomass and organic soil carbon, according to the following equation:

$$TCeq_i = ((TB_{forest\ class,i} - TB_{post\ def\ class,i}) + (SOC_{forest\ class,i} - SOC_{post\ def\ class,i}) * DR) * CF * (44/12) \quad (19)$$

Where:

$TCeq,i$	=	Total carbon emission factor in all carbon pools included,at vegetation type i,t CO2eq/ha

$TBforest\ class, i$	=	Total biomass stock in all carbon pools included in the forest class,at vegetation type i (t d.m./ha)
$TBpost\ def\ class, i$	=	Total biomass stock in all carbon pools included in the post def.class,at vegetation type i (t d.m./ha)
$SOC_{forest\ class,i}$	=	Total biomass stock in the SOC pool in the forest class,at vegetation type i (t d.m./ha)
$SOC_{post\ def\ class,i}$	=	Total biomass stock in the SOC pool in the post deforestation class,at vegetation type i (t d.m./ha)
DR	=	SOC Decay Rate: 1/20,(1/yr)
CF	=	Carbon fraction (IPCC 0.47), (dimensionless)
$44/12$	=	The molecular ratio constant between carbon (C) and carbon dioxide (CO_2))
t	=	1,2,3...T (dimensionless)
i	=	1,2,3...N,number of vegetation types (dimensionless)

12.3.10 Forest degradation carbon stock change

12.3.10.1 Illegal extraction

The calculation procedure is identified through remote sensing techniques[58] the degraded areas in the reference period within the project area or in the control plot area to establish the annual carbon emissions due the illegal extraction occurred in the reference period. After, the project holder shall choose a $ADeg$ preferably within the project area or in the control plot area to estimate the extension of damage in the forestry.

This area will be sampled by surveying multiple transects of known length and width across the access-buffer area (equal in area to at least 0.5% of $ADeg$) to see if recent tree stumps are visible. Degradation in this area can be presumed to be zero if there is little to no indication that trees were being harvested.

If the limited sampling identifies that trees are being removed from the buffer area the sampling strategy shall be created utilizing plots that are methodically distributed over the buffer zone in order to sample at least 3% of the buffer zone's area ($ADeg$). For each tree will be measured the stump's diameter and make the conservative assumption that it matches the DBH. Determine a ratio between the diameter at DBH and the diameter of

[58] NDFI or similar

the buttress at the same height above ground as the measured stumps if the stump is a huge buttress.

This ratio will be applied to the measured stumps to estimate the likely DBH of the cut tree. The above and below ground carbon stock of each harvested tree shall be estimated using the same allometric regression equation and root to shoot ratio used in estimating the carbon pool in trees in the baseline scenario. The mean above and below ground carbon stock of the harvested trees is conservatively estimated to be the total emissions and to all enter the atmosphere.

$$\Delta Tdeg_{t,i} = Adeg_{t,i} * (Tdeg_{t,i}/Asp_{t,i}) * CF * (44/12) \quad (20)$$

Where:

$\Delta Tdeg_{t,i}$	=	Degradation C stock change as a result of illegal extraction,at time t,at vegetation type i, tCO_2e/ha
$Adeg_{t,i}$	=	Degradation total area within the project area or in the control plots,at time t,at vegetation type i (ha)
$Tdeg_{t.i}$	=	Tree cuts biomass from the sample plots area at time t,at vegetation type i (t d.m.)
$Asp_{t,i}$	=	Total area of the degradation sample plots area at time t,at vegetation type i (ha)
CF	=	Carbon fraction (IPCC 0.47), (dimensionless)
$44/12$	=	The molecular ratio constant between carbon (C) and carbon dioxide (CO_2))
t	=	1,2,3…T (dimensionless)
i	=	1,2,3…N,number of vegetation types (dimensionless)

12.3.10.2 Sustainable Forest management

The calculation procedure for estimating net emissions and removals related to selective logging activities in the project baseline scenario will be equal to the summed emissions arising from selective logging operations during all the years from the reference period. It is only applicable where the project holder is able to prove with official documents that a defined area within the project area had log activities during the reference period.

The project holder shall disclose all the documents used to request the forest management plan approval for the conformance analysis of competent public agencies responsible for this theme. This documentation shall contain all the steps of the logging cycle with the estimation of volume per hectare per year. Also, it's necessary to disclose the documents of the real volume logged per hectare*year to establish the real impact of the logging activities due the forest management.

So, the net baseline emissions from the logging activities are defined by a sum of two main aspects:

(a) Emissions from logging gap: emissions from fallen trees;

(b) Emissions from timber extraction.

$$\Delta Tlog_{t,i} = ((Tlog,gap_{t,i} + Tlog,timber_{t,i})\ x\ CF\ x\ (44/12)) \quad (21)$$

Where:

$\Delta Tlog_{t,i}$	=	Degradation carbon stock change as a result of logging activities,at time t,at vegetation type i,tCO2eq/ha
$Tlog,gap_{t,i}$	=	Degradation from logging gaps in the project area,at time t,at vegetation type i,t d.m./ha
$Tlog,timber_{t,i}$	=	Degradation from timber extraction,at time t,at vegetation type i,t d.m./ha
CF	=	Carbon fraction (IPCC 0.47) [59], (dimensionless)
44/12	=	The molecular ratio constant between carbon (C) and carbon dioxide (CO2))
t	=	1,2,3…T (dimensionless)
i	=	1,2,3…N,number of vegetation types (dimensionless)

12.3.10.3 Burned areas

To identify, map and estimate the total area burned in the project area or in the control plots area in the reference period to establish the baseline scenario of this degradation activity it's necessary to apply the NBR index. After it was possible to quantify the burned

[59] IPCC values available in Proposal to integrate AFOLU

annual area in the reference period, the project holder shall estimate the associated GEE emissions due the forest fires using the IPCC 2006 Inventory Guidelines[60].

$$L_{fires,t,i} = \sum_{n=1}^{N} \left(A_{burned,t,i} \times B_{w,i} \times G_{ef} \times C_f \times 10^{-3}\right) \times CF \times \left({}^{44}/_{12}\right) \quad (22)$$

Where:

$L_{fires,t,i}$	=	Annual losses of GHG (CO_2,CO,CH_4 e NH_4) due the forest fires,at year t,at vegetation type i,t CO_2e/ ha
$A_{burned,t,i}$	=	Area affected by fires,at year t,at vegetation type i,ha
$B_{w,i}$	=	mass of biomass available for combustion,at vegetation type i,t d.m./ ha
Gef	=	emission factor for all GHG included in the calculation,g/kg,(IPCC 2006,table 2.5) [61]
Cf	=	combustion factor,(IPCC 2006,Table 2.6) [62], (dimensionless)
CF	=	Carbon fraction (IPCC 0.47) [63], (dimensionless)
44/12	=	The molecular ratio constant between carbon (C) and carbon dioxide (CO_2))
t	=	1,2,3…T (dimensionless)
n	=	1,2,3…N,number of GHG included in the calculation (dimensionless)
i	=	1,2,3…N,number of vegetation types (dimensionless)

12.4 Estimated GHG emissions reductions (ex-ante)

The following conservative approach is required the project holder must assume that the future deforestation will happen first in the strata with the lowest carbon stocks (in all selected carbon pools) in the project and leakage areas.

12.4.1 Deforestation baseline emissions

The annual emission due to deforestation in reference region baseline scenario is estimated with the following equation:

[60] https://www.ipcc-nggip.iges.or.jp/public/2006gl/vol4.html
[61] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_02_Ch2_Generic.pdf
[62] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_02_Ch2_Generic.pdf
[63] IPCC values available in Proposal to integrate AFOLU

$$AE_{R,bl,t,i} = FSC_{R,bl,t,i}\ x\ TC_{eq,i} \tag{23}$$

Where:

$AE_{bl,t,i}$	=	Annual emission in the baseline scenario, in the reference region, at time t; tCO2/ha[1]
$FSC_{bl,t,i}$	=	Historical annual deforestation in the baseline scenario, in the reference region; at time t, ha
$TC_{eq,i}$	=	Total carbon emission factor; tCO2e ha^{-1}
t	=	1,2,3…T (dimensionless)
i	=	1,2,3…N,number of vegetation types (dimensionless)

The annual emissions from deforestation in the control plots area baseline scenario are estimated using the following equation:

$$AE_{bl,CP,t,i} = FSC_{CP,BL,t,i}\ x\ TC_{eq,i} \tag{24}$$

Where:

$AE_{bl\ A,t,i}$	=	Annual emission in the baseline scenario, in the control plot area; at time t, at vegetation type i, tCO2/ha
$FSC_{CP,BL,t,i}$	=	Historical annual deforestation in the baseline scenario, in the control plot area; at time t, at vegetation type i, ha
$TC_{eq,i}$	=	Total carbon emission factor; at vegetation type i, tCO2e/ha
t	=	1,2,3…T (dimensionless)
i	=	1,2,3…N,number of vegetation types (dimensionless)

The annual emissions from deforestation in the project area baseline scenario are estimated using the following equation:

$$AE_{bl\ A,t,i} = FSC_{A,bl,t,i} x\ TC_{eq,i} \tag{25}$$

Where:

$AE_{bl\ A,t,i}$		Annual emission in the baseline scenario, in the project area; at time t, at vegetation type i, tCO2/ha
$FSC_{A,bl,t,i}$		Historical annual deforestation in the baseline scenario, in the project area; at time t, at vegetation type i, ha
$TC_{eq,i}$	=	Total carbon emission factor; at vegetation type i, tCO2e/ha
t	=	1,2,3…T (dimensionless)
i	=	1,2,3…N,number of vegetation types (dimensionless)

The annual emission due to deforestation in the baseline scenario, for the leakage area is estimated as follows:

$$AE_{bl,lk,t,i} = FSC_{bl,lk,t,i}\ x\ TC_{eq.i} \quad (26)$$

Where:

$AE_{bl,lk,t,i}$	=	Baseline annual emission in the leakage area; year, at time t, at vegetation type i, tCO2/ha
$FSC_{bl,lk,t,i}$	=	Baseline annual historical deforestation in leakage area; at time t, at vegetation type i, ha
$TC_{eq,i}$	=	Total carbon emission factor; at vegetation type i, tCO2e/ ha
t	=	1,2,3…T (dimensionless)
i	=	1,2,3…N,number of vegetation types (dimensionless)

12.4.2 Emissions in the project scenario

Annual emissions from deforestation in the project area, are calculated as follows:

$$AE_{REDD+project,t,i} = FSC_{REDD+project,t,i}\ x\ TC_{eq,i} \quad (27)$$

Where:

$AE_{REDD+project,t,i}$	=	Annual emission in the project scenario, in the project area; at time t, at vegetation type i, tCO2/ha
$FSC_{REDD+project,t,i}$	=	Annual change in forest cover in the project area, in the project scenario; at time t, at vegetation type i, ha
$TC_{eq,i}$	=	Total carbon emission factor; at vegetation type i, tCO2e/ ha
t	=	1,2,3...T (dimensionless)
i	=	1,2,3...N,number of vegetation types (dimensionless)

The annual emissions caused by deforestation in the leakage area are calculated according to the following equation:

$$AE_{lk,project,t,i} = FSC_{lk,project,t,i} x\, TC_{eq,i} \quad (28)$$

Where:

$AE_{lk,project,t,i}$	=	Annual emission in the project scenario, in the leakage area; at time t, at vegetation type i, tCO2/ha
$FSC_{lk,project,t,i}$	=	Annual change in forest cover in the leakage area, in the project scenario; at vegetation type i, ha
$TC_{eq,i}$	=	Total carbon emission factor; at vegetation type i, tCO2e/ha
t	=	1,2,3...T (dimensionless)
i	=	1,2,3...N,number of vegetation types (dimensionless)

12.4.3 Degradation baseline emissions

The annual emission due to forest degradation in the project area baseline scenario is estimated with the following equation:

$$AE_{A,Deg,bl,t} = \sum_{i=1}^{N}((\Delta Tdeg_{t,i} xFDeg_{A,bl,fires,i,t}) + (\Delta Tlog_{i,t} xFDeg_{A,bl,log,i,t}) + (L_{fires,i,t} xFDeg_{A,bl,fires,i,t})) \quad (29)$$

Where:

$AE_{A,Deg,bl,t,i}$	=	Baseline annual emission from degradation within the project area at year t;at vegetation type i,tCO2/yr

$FDeg_{A,bL,ext,t,i}$	=	Baseline scenario of illegal extraction within the project area at year t,at vegetation type i,ha
$FDeg_{A,bl,log,t,i}$	=	Baseline scenario of logging activities within the project area at year t; at vegetation type i,ha
$FDeg_{A,bl,fire,t,i}$	=	Baseline scenario of fires within the project area at year t; at vegetation type i,ha
$L_{fires,t,i}$	=	Annual losses of GHG (CO_2,CO,CH_4 e NH_4)due the forest fires,at year t; at vegetation type i,tCO_2e
$\Delta Tdeg_{t,i}$	=	Degradation total carbon stock change as a result of illegal extraction,at year t; at vegetation type i,tCO_2e
$\Delta Tlog_{t,i}$	=	Degradation carbon stock change as a result of logging activities,at year t; at vegetation type i,tCO_2eq
t	=	1,2,3,...T year of the baseline annual degradation projection
i	=	1,2,3,...N number of vegetation types

The annual emission by degradation in the leakage area is calculated, following the equation:

$$AE_{lk,Deg,bl,t,i} = \left(\Delta TDeg_{i,t} x FDeg_{lk,bl,ext,t,i}\right) + \left(\Delta Tlog_{t,i} x FDeg_{lk,bl,log,t,i}\right) + \left(L_{fires,i} x FDeg_{lk,bl,fires,t,i}\right) \quad (30)$$

Where:

$AE_{lk,Deg,bl,t,i}$	=	Baseline annual emission from degradation within the leakage area at year t;at vegetation type i,tCO_2/yr
$FDeg_{lk,bL,ext,t,i}$	=	Baseline scenario of illegal extraction within the leakage area at year t,at vegetation type i,ha
$FDeg_{lk,bl,log,t,i}$	=	Baseline scenario of logging activities within the leakage area at year t; at vegetation type i,ha
$FDeg_{lk,bl,fire,t,i}$	=	Baseline scenario of fires within the leakages area at year t; at vegetation type i,ha
$L_{fires,t,i}$	=	Annual losses of GHG (CO_2,CO,CH_4 e NH_4) due the forest fires,at year t; at vegetation type i,tCO_2e
$\Delta Tdeg_{t,i}$	=	Degradation total carbon stock change as a result of illegal extraction,at year t; at vegetation type i,tCO_2e

$\Delta Tlog_{t,i}$	=	Degradation carbon stock change as a result of logging activities,at year t; at vegetation type i,tCO2eq
t	=	1,2,3,...T year of the baseline annual degradation projection
i	=	1,2,3,...N number of vegetation types

12.4.4 Degradation emissions in the project scenario (ex-ante)

Annual emissions from degradation in the project area, are calculated as follows:

$$AE_{A,Deg,proj,t,i} = (\Delta Tdeg_{t,i}\ x\ PFD_{REDD+project,deg,t,i}) + (\Delta Tlog_{t,i}\ x\ PFD_{REDD+project,log,t,i}) + (L_{fires,i}\ x\ PFD_{REDD+project,fires,t,i}) \quad (31)$$

Where:

$AE_{A,Deg,proj,t,i}$	=	Project annual emission from degradation within the project area,at year t,at vegetation type i,tCO2/yr
$PFD_{REDD+project,deg,t,i}$	=	Project annual emission from degradation within the project area,at year t,at vegetation type i,tCO2/yr
$PFD_{REDD+project,log,t,i}$	=	Annual forest illegal extraction in the project area,at year t,at vegetation type i,in project scenario; ha
$PFD_{REDD+project,fires,t,i}$	=	Annual forest logging activities in the project area,at year t,at vegetation type i,in project scenario; ha
$L_{fires,t,i}$	=	Annual forest fires in the project area,at year t,at vegetation type i,in project scenario; ha
$\Delta Tdeg_{t,i}$	=	Annual losses of GHG (CO2,CO,CH4 e NH4) due the forest fires,at year t,at vegetation type i,t CO2e
$\Delta Tdeg_{t,i}$	=	Degradation total carbon stock change as a result of illegal extraction,at year t,at vegetation type i,tCO2e
$\Delta Tlog_{t,i}$		Degradation carbon stock change as a result of logging activities,at year t,at vegetation type i,tCO2eq/ha
t	=	1,2,3,...T year of the baseline annual degradation projection
i	=	1,2,3,...N number of vegetation types

Annual emissions from degradation in the leakage area, are calculated as follows:

$$AE_{lk,Deg,proj,t,i} = (\Delta Tdeg_{t,i}\ x\ PFD_{lk,deg,t,i}) + (\Delta Tlog_{t,i}\ x\ PFD_{lk,log,t,i}) + (L_{fires,i}\ x\ PFD_{lk,fires,t,i}) \quad (32)$$

Where:

$AE_{lk,Deg,proj,t,i}$	=	Project annual emission from degradation within the leakage area,at year t,at vegetation type i,tCO2e
$PFD_{lk,deg,t,i}$	=	Annual forest illegal extraction in the leakage area,at year t,at vegetation type i,in project scenario; ha
$PFD_{lk,log,t,i}$	=	Annual forest logging activities in the leakage area,at year t,at vegetation type i,in project scenario; ha
$PFD_{lk,fires,t,i}$	=	Annual forest fires in the leakage area,at year t,at vegetation type i,in project scenario; ha
$L_{fires,t,i}$	=	Annual losses of GHG (CO_2,CO,CH_4 e NH_4)due the forest fires,at year t,at vegetation type i,t CO_2e
$\Delta Tdeg_{t,i}$	=	Degradation total carbon stock change as a result of illegal extraction,at year t,at vegetation type i,tCO2e
$\Delta Tlog_{t,i}$	=	Degradation carbon stock change as a result of logging activities,at year t,at vegetation type i,tCO2eq/ha
t	=	1,2,3,...T year of the baseline annual degradation projection
i	=	1,2,3,...N number of vegetation types

12.5 GHG emissions reduction in the project scenario (ex-ante scenario)

12.5.1 Emission reduction due to avoided deforestation (ex-ante)

The emission reduction due to avoided deforestation is estimated with the following equation:

$$ER_{DEF,REDD+Project,t} = \left(\sum_{i=1}^{N}\left(AE_{bl.A,t,i} - AE_{REDD+project,t,i}\right) - \sum_{i=1}^{N}\left(AE_{bl,lk,t} - AE_{lk,project,t}\right)\right) \quad (33)$$

Where:

$ER_{DEF,REDD+project,t}$	=	Emission reduction due to avoided deforestation; tCO2e at year t
$AE_{bl,A,t,i}$	=	Annual emission by deforestation in the baseline scenario; at year t, at vegetation type i. tCO2e
$AE_{REDD+project,t,i}$	=	Annual emission by deforestation in the project scenario; at year t, at vegetation type i, tCO2/ha
$AE_{bl,lk,t,i}$	=	Baseline annual emission in the leakage area; year, at year t, at vegetation type i, tCO2/ha
$AE_{lk,project,t,i}$	=	Annual emission by deforestation in the leakage area, in the project scenario; at year t, at vegetation type i, tCO2/ha
t	=	1,2,3…T, years (dimensionless)
i		1,2,3…N number of vegetation types

Leakage will be calculated as the difference between ex-ante and ex-post analysis. If $AE_{bl,lk,t} < AE_{lk,project,t}$ it will be considered activity displacement leakage, so the leakage value adopted to calculate the ex-ante project reductions emissions will be the $AE_{lk,project,t}$.

12.5.2 Emission reduction due to avoided forest degradation (ex-ante)

The emission reduction due to avoided forest degradation is estimated with the following equation:

$$ER_{FD,REDD+Project,t} = \left(\sum_{i=1}^{N}\left(AE_{A,Deg,bl.A,t,i} - AE_{A,Deg,project,t,i}\right) - \sum_{i=1}^{N}\left(AE_{lk,Deg,bl,t,i} - AE_{lk,Deg,project,t,i,t}\right)\right) \quad (34)$$

Where:

$ER_{FD,REDD+project,t}$	=	Emission reduction due to avoided forest degradation; at year t; tCO2e
$AE_{A,Deg,proj,t,i}$	=	Project annual emission from degradation within the project area,at year t at vegetation type i,; tCO2
$AE_{A,Deg,bl,t,i}$	=	Baseline annual emission from degradation within the project area at year t; at vegetation type i,tCO2
$AE_{lk,Deg,proj,t,i}$	=	Project annual emission from degradation within the leakage area at year t; at vegetation type i,tCO2

$AE_{lk,Deg,bl,t,i}$	=	Baseline annual emission from degradation within the leakage area at year t; at vegetation type i,tCO_2
t	=	1,2,3…T, years (dimensionless)
i		1,2,3…N number of vegetation types

Leakage will be calculated as the difference between ex-ante and ex-post analysis. If $AE_{lk,Deg,blt} < AE_{lk,Deg,project,t}$ it will be considered activity displacement leakage, so the leakage value adopted to calculate the ex-ante project reductions emissions will be the $AE_{lk,Degproject,t}$.

13 Monitoring plan

The project holder shall develop and implement a plan for monitoring changes in relevant carbon pools, non-CO_2 GHGs and emissions sources and leakage using an approved or defensible methodological approach and following the defined frequency of monitoring of defined parameters. The plan shall be described in a SOP document the procedures established to monitor the project activities implementation, the safeguards compliance, and the GHG emission reduction in the Project.

The monitoring plan shall include the following features:

(a) Monitor the applicability conditions listed in numeral 5 of this document have been met;

(b) Monitor the implementation of the project activities and safeguards compliance;

(c) Monitor actual carbon stock changes and GHG emissions in the project area;

(d) Monitor the associated leakage emissions;

(e) Ex-post calculations of the VCCs

The data collected shall be archived for a minimum of one year and a maximum of five years of the start of the project or the end of the previous monitoring period.

The SOP of the monitoring plan shall contain the following sections to describe the features status implementation:

(a) Technical description of the monitoring activities

(b) Data to be collected

(c) Overview of the data collect procedures

(d) Quality control and quality assurance procedures

(e) Data archiving

(f) Organization and responsibilities of the parties involved

13.1 Monitoring the project boundaries

The Project's geographic limits, constituted by: reference region, project area, control plots area and leakage area shall be periodically monitored, especially to: identify any risk of non-permanence of the carbon stock inside of the project area, update if it's necessary the deforestation and/or degradation baseline scenarios based in the newest remote sensing data and to identify potential displacement of the deforestation agents to other areas due the project activities implementation.

It's a good practice to monitor the forest cover inside of the project areas with a monthly frequence because the results of the monitoring activities can support any mitigation activities of the identified event of deforestation and degradation, such as communication with the surveillance environmental agencies or other public agency that has the legal attribution of protect the forest according to the National or State Legislation. Besides this suggestion, the project holder shall report each year along the project lifetime the monitoring results.

13.2 Monitoring of the REDD+ activities implementation

The REDD+ project holder shall design a monitoring plan for each proposed activity, according to the following table's information and based on the TOC approach described in the section 11 of this document.

Table 3. Monitoring of the REDD+ activities implementation

Activity ID	
Indicator ID	
Indicator name	
Type[64]	
Goal[65]	
Measurement unit	
Monitoring methodology	
Monitoring frequency	

[64] Result, product or impact.
[65] Expected value and time for compliance.

Responsible for measurement	
Result indicator in the reporting period	
Documents to support the information	
Observations	

13.3 Monitoring of the REDD+ Safeguards

Create and carry out a monitoring plan that specifies the following: the types of measures, the sampling techniques, the frequency of monitoring and reporting, the communities, community groups, and other stakeholders to be monitored, and the community variables to be monitored.

The project's goals for communities and community groups, as well as the anticipated outputs, outcomes, and impacts found in the project's causal model pertaining to community well-being (defined in TOC section 11), shall be closely connected to the monitoring variables. Every community group shall have its distinct impacts, including costs, risks, and benefits, evaluated by the impacted community groups as part of the monitoring process.

The REDD+ project holder shall design a monitoring plan for each safeguard with the following table's information.

Table 4. Monitoring of the REDD+ Safeguards

Safeguard ID	
Indicator ID	
Indicator name	
Type	
Goal	
Measurement unit	
Monitoring methodology	
Monitoring frequency	
Responsible for measurement	
Result indicator in the reporting period	
Documents to support the information	

Observations	

13.4 Monitoring of the project non-permanence risk

The project holder shall monitor the identified risks of project permanence and design a monitoring plan that includes mitigation measures, monitoring indicators, and reporting procedures[66]. Biophysical and socioeconomic risks should be assessed, including fires, floods, land tenure disputes, conflicts between project stakeholders, non-ownership of project activities, and governance failures.

The project holder shall apply the BCR Tool “Permanence and risk management” and if applicable during the verification of the monitoring period the project holder can update the non-permanence risk analysis and validate again with new data and information. [67]

13.5 Monitoring of the project emissions

In the project scenario all activity data shall be monitored. Validated emission factors can be applied in the estimation of monitored emissions[68]. The parameters for the estimation of activity data shall be determined following the guidelines in Section 14.2.

Also, for remote sensing analysis, specifically to monitor the forest cover of the reference region, project area, control plots area and leakage area, the project holder needs to use the same methods used to determine the baseline scenario in section 10.2, as described below:

(a) collect the appropriate remote sensing data,

(b) methods employed in the remote sensing analysis (pre-processing, interpretation/classification and post-processing),

(c) accuracy analysis: a validation process of all the land use maps used in this section with statistical analysis and index with a acceptable error of 10% of the classification between the ground-truth and the image classified

The GHG Project holder shall demonstrate that emission reductions or removals are quantified, monitored, reported and verified, applying the BCR Tool “Monitoring, reporting and verification (MRV)” [69].

[66] In the event of fires, the affected area shall be identified, CO_2 and CH_4 emissions shall be estimated and included in the quantification of the project's emissions during the monitoring period.
[67] https://biocarbonstandard.com/wp-content/uploads/risk-and-permanence.pdf
[68] The REDD+ Project holder shall review and adjust the activity data and emission factors according to the national official information and data.
[69] https://biocarbonstandard.com/wp-content/uploads/BCR_Monitoring-reporting-and-verification.pdf

14 GHG emissions reductions in the monitoring period (ex-post)

14.1 Actual GHG emissions

14.1.1 Deforestation

The annual emission due to deforestation in the project area is estimated with the following equation:

$$AE_{A,REDD+project,t} = \sum_{i=1}^{N} (AD_{A,REDD+project,i,t} \ x \ TC_{eq,i}) \qquad (36)$$

Where:

$AE_{REDD+project,t}$	=	Net carbon stock change of deforestation in the project scenario in the project area; at time t, tCO2/ha
$AD_{REDD+project,i,t}$	=	Annual monitored deforestation in the project area; at time t, at vegetation type i, ha
$TC_{i,eq}$	=	Total carbon emission factor, at vegetation type i, tCO2e/ha
i	=	1,2,3…N, number of vegetation types
t	=	1,2,3…T (dimensionless)

The annual emission due to deforestation in the leakage area is estimated as follow:

$$AE_{lk,t} = \sum_{i=1}^{N} \left(AD_{lk,i,t} \ x \ TC_{i,eq}\right) \qquad (37)$$

Where:

$AE_{lk,t}$	=	Annual emission in the leakage area; at year t, tCO2 ha^{-1}
$AD_{lk,t,i}$	=	Annual deforestation in leakage area, at vegetation type i, at year t, ha
$TC_{i,eq}$	=	Total carbon dioxide equivalent; at vegetation type I, tCO2e/ha
i	=	1,2,3…N, number of vegetation types

t	=	1,2,3...T, years (dimensionless)

14.1.2 Actual degradation

The annual emission due to forest degradation in the project area in the project scenario is estimated with the following equation:

$$AE_{A,Deg,proj,t} = \sum_{i=1}^{N} (\Delta Tdeg_{i,t} * FDeg_{A,proj,ext,i,t} + \Delta Tlog_{i,t} * FDeg_{A,proj,log,i,t} + L_{fires,i} * FDeg_{A,proj,fires,i,t}) \quad (38)$$

Where:

$AE_{A,Deg,proj,t}$	=	Annual emission from degradation within the project area at year t;tCO2
$FDeg_{A,proj,ext,t,i}$	=	Area of illegal extraction within the project area at year t;at vegetation type i,ha
$FDeg_{A,proj,log,t,i}$	=	Area of logging activities within the project area at year t;at vegetation type i,ha
$FDeg_{A,proj,fire,t,i}$	=	Burned areas within the project area at year t; at vegetation type i,ha
$L_{fires,t,i}$	=	Annual losses of GHG (CO2,CO,CH4 e NH4) due the forest fires,at year t; at vegetation type i,tCO2e/ha
$\Delta Tdeg_{t,i}$	=	Degradation total carbon stock change as a result of illegal extraction,at year t,at vegetation type i,tCO2e/ha
$\Delta Tlog_{t,i}$	=	Degradation carbon stock change as a result of logging activities,at vegetation type i,tCO2eq/ha
i	=	1,2,3...N, number of vegetation types (dimensionless)
t	=	1,2,3...T, years (dimensionless)

The annual emission due to forest degradation in the leakage area in the project scenario is estimated with the following equation:

$$AE_{lk,Deg,proj,t} = \sum_{i=1}^{N} \Delta Tdeg,i * FDeg_{lk,proj,ext,i,t} + \Delta Tlog_{i,t} * FDeg_{lk,proj,log,i,t} + L_{fires,i,t} * FDeg_{lk,proj,fires,i,t}) (\quad (39)$$

Where:

$AE_{A,Deg,proj,t}$	=	Annual emission from degradation within the leakage area at year t;tCO2/yr
$FDeg_{A,proj,ext,t,i}$	=	Area of illegal extraction within the leakage area at year t; at vegetation type i,ha
$FDeg_{A,proj,log,t,i}$	=	Area of logging activities within the leakage area at year t;at vegetation type i,ha
$FDeg_{A,proj,fire,t,i}$	=	Burned areas within the leakage area at year t;at vegetation type i,ha
$L_{fires,t,i}$	=	Annual losses of GHG (CO2,CO,CH4 e NH4) due the forest fires,at vegetation type i,tCO2e/ha
$\Delta Tdeg_{t,i}$	=	Degradation total carbon stock change as a result of illegal extraction,at time t,at vegetation type i,tCO2e/ha
$\Delta Tlog_{t,i}$	=	Degradation carbon stock change as a result of logging activities,at vegetation type i,tCO2eq/ha
t	=	1,2,3,...T year of the baseline annual degradation projection
i	=	1,2,3,...N number of vegetation types

14.2 Quantification of the project emissions reduction (ex-post)

The following conservative approach is required the project holder must assume that the future deforestation will happen first in the strata with the lowest carbon stocks (in all selected carbon pools) in the project and leakage areas.

14.2.1 Emission reduction due to avoided deforestation (ex-post)

The emission reduction due to avoided deforestation is estimated with the following equation:

$$ER_{DEF,REDD+project,t} = \left((AE_{bl,A,t} - AE_{REDD+project,t}) - (AE_{bl,lk,t} - AE_{lk,project,t})\right) \quad (40)$$

Where:

$ER_{DEF,REDD+project,t}$	=	Emission reduction due to avoided deforestation; tCO2e at year t
$AE_{bl,A,t}$	=	Annual emission by deforestation in the baseline scenario; at year t, tCO2e
$AE_{REDD+project,t}$	=	Annual emission by deforestation in the project scenario; at year t, tCO2
$AE_{lk,project,t}$	=	Annual emission by deforestation in the leakage area, in the project scenario; at year t, tCO2
$AE_{bl,lk,t}$	=	Annual emission by deforestation in the leakage area, in the baseline scenario; at year t, tCO2
t	=	Annual emission by deforestation in the leakage area, in the baseline scenario; at year t, tCO2

Leakage will be calculated as the difference between ex-ante and ex-post analysis. If $AE_{bl,lk,t} < AE_{lk,project,t}$ it will be considered activity displacement leakage, so the leakage value adopted to calculate the actual project reductions emissions will be the monitored one ($AE_{lk,project,t}$).

14.2.2 Emission reduction due to avoided forest degradation (ex-post)

The emission reduction due to avoided forest degradation is estimated with the following equation:

The emission reduction due to avoided forest degradation is estimated with the following equation:

$$ER_{FD,REDD+project,t} = ((AE_{A,Deg,bl,t} - AE_{A,Deg,project,t}) - (AE_{lk,Deg,bl,t} - AE_{lk,Deg,project,t})) \quad (41)$$

Where:

$ER_{FD,REDD+project,t}$	=	Emission reduction due to avoided forest degradation,at year t; tCO2e

$AE_{A,Deg,bl,t}$	=	Annual emission from degradation within the project area,at year t; tCO2
$AE_{A,Deg,project,t}$	=	Baseline annual emission from degradation within the project area at year t; tCO2
$AE_{lk,Deg,bl,t}$		Baseline annual emission from degradation within the leakage area at year t;tCO2
$AE_{lk,Deg,project,t}$		Annual emission from degradation within the leagage area at year t; tCO2

14.3 Verified Carbon Credits (ex-post)

The total emission reduction due to avoided forest deforestation and degradation in the project scenario is estimated with the following equation:

$$VCC_t = \Bigg(\Big(\big((AE_{A,Deg,bl,t} - AE_{A,Deg,proj,t}\big) + \big(AE_{bl,A,t} - AE_{REDD+project,t}\big) - \big(AE_{lk,Deg,proj,t} + AE_{lk,project,t}\big)\Big) * (1 - Utotal)\big) - (((AE_{A,Deg,bl,t} - AE_{A,Deg,proj,t}\big) + \big(AE_{bl,A,t} - AE_{REDD+project,t}\big)) * (\%Buffer))\Bigg) \quad (42)$$

Where:

VCC_t	=	Verified carbon credits,due the emissions reductions of the REDD+ project,at time t,unit
$ER_{FD,REDD+project,t}$	=	Emission reduction due to avoided forest degradation,at year t; tCO2e
$ER_{DEF,REDD+project,t}$	=	Emission reduction due to avoided forest deforestation,at year t; tCO2e
$\%Buffer$	=	% of VCCs that will be withholding to secure the risk of non permanence[70]
$Utotal$	=	% of uncertainty due the error propagation of the calculus process
t	=	1,2,3...T (dimensionless)

[70] BCR_risk-and-permanence.pdf

The project holder shall use the Avoiding double counting tool (ADC tool[71]) from the Biocarbon standard to guarantee that the VCC generated by the project is in conformance with the article 6.2 and 6.4 of the Paris Agreement and Corsia requirements.

15 Quality control and quality assurance procedures

The REDD+ project holder shall design a quality management and assurance system to ensure the proper management, quality, and reliability of the information. The Quality Control/Assurance Control (QA/QC) system should conform to IPCC recommendations[72]. To provide consistency in the processes, protocols, and manuals should be developed for all project activities. The QA/QC process should include, in a complementary manner, what is described in the following sections.

15.1 Review of the information processing

The processing of the data collected in the field and the digital systems recording should be reviewed. The recorded data should be reviewed using a sample of 10% of the records (selected at random) to identify possible inconsistencies. If there are errors, a percentage estimate of the errors should be made. The typing error should not exceed 10%, in which case the entire data should be reviewed, and the necessary corrections made.

15.2 Data recording and archiving system

The information should be stored in an organized and secure manner in digital and physical formats with sufficient copies (depending on the personnel in charge). In general, each file should contain field forms, estimates of carbon content changes (equations and calculations), geographic information (GIS)[73], and measurement and monitoring reports.

According to the Methodology, the data collected shall be archived for at least two years after the project activity's last accreditation period.

[71] BioCarbon_ADC Tool
[72] IPCC GPG LULUCF (2005). http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf/spanish/full.pdf
[73] Geographic information shall be handled following the quality standards.

Document history

Type of document. Methodological Document for REDD+ projects

Version	Date	Nature of the review
1.0	February 3, 2020	Initial version – Document submitted for public consultation
2.0	April 13, 2020	Updated version – After consultation
2.1	June 5, 2020	Adjusted version Reference region Leakage area Activity data Some terms and definitions
2.2	February 5, 2021	Adjusted version Editorial changes Notation in some equations
3.0	February 16, 2022	Actualized version Normative references Definitions REDD+ safeguards Minor Editorial Changes Copyright BioCarbon Registry
3.1	September 15, 2022	Actualized version GHG Sources. Soil Organic Carbon, optional Minor Editorial Changes
4.0	May 27, 2024	Actualized version Scope Conditions of applicability Version and validity Terms and definitions Uncertainty management Emission reduction quantification Copyright BioCarbon Cert

4.1 Public consultation	May 19, 2025	Actualized version Project boundaries; Control plots; Definition and estimative of the Baseline scenario; Carbon stocks and carbon stocks changes; Degradation estimative; Monitoring protocol.