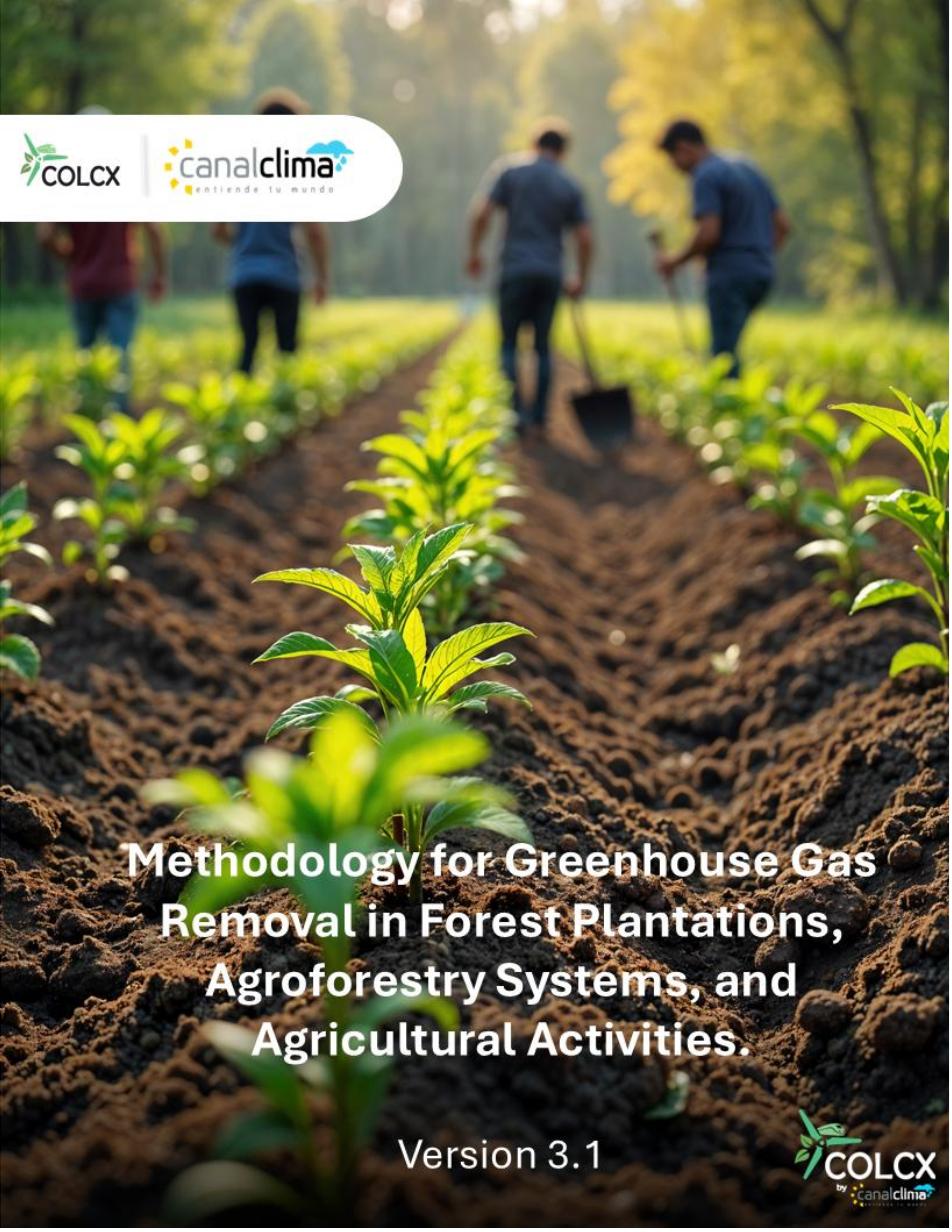

Methodology for Greenhouse Gas Removal in Forest Plantations, Agroforestry Systems, and Agricultural Activities.

Version 3.1

Methodology for Greenhouse Gas Removals in Forest Plantations, Agroforestry Systems, and Agricultural Activities

Version 3.1

CONTENT

TABLES

1 DEFINITIONS[1]

- **Activity Data (AD):** Activity data refers to the measured magnitude of a parameter used to evaluate initiative activities that generate emissions or removals. For example, the area covered by an ecosystem (ha), soil bulk density (g/cm^3), etc.
- **Afforestation:** The planting or sowing of tree species in areas with no historical presence of forest cover.
- **Agroforestry Systems:** Areas with multipurpose arrangements (to produce fiber, fodder, fruits, etc.) that combine forest species (trees or shrubs) with agricultural species of herbaceous, shrub, or tree types. These arrangements involve associations of permanent and semi-permanent crops (e.g., cacao, coffee, and fruit trees mixed with forest species) sharing the same geographical production area. Forest species in these systems may function as windbreaks, live fences, or shade for the shrub or herbaceous crops.
- **Emission Factors (EF):** These correspond to coefficients that represent the average amount of greenhouse gas emissions or removals associated with a particular system.
- **Forest Plantations:** Anthropogenic land cover composed of tree vegetation established for forest management purposes, with one or multiple production objectives (e.g., timber, non-timber forest products, or other ecosystem goods and services). They may be established in several areas, provided that the soil conditions are suitable. These plantations may consist of a single species or a mixture of species.
- **Fruit Tree Crops:** For the purposes of this methodology, these are areas distinct from permanent shrub crops, where arboreal species predominate, including medium-sized trees such as cacao (*Theobroma cacao L.*), copoazú (*Theobroma grandiflorum (Wild. ex Spreng.) K. Schum.*), among others, which share similar characteristics (height and well-defined crown). These are mainly established for fruit production.
- **Land-Use Change:** The transformation of the current use of land associated with a particular land cover or area. This directly affects geographic, economic, political, social, demographic, and cultural factors.
- **Oil Palm Crops:** The cultivation of African oil palm (*Elaeis spp.*) for oil production.
- **Organic Soils:** Soils with at least 12% organic carbon. These can be identified by the thickness of their organic horizon and the absence of water saturation.
- **Permanent Shrub Crops:** Land covers composed primarily of shrub-like crop species. Shrubs are understood as perennial plants with woody stems, ranging from 0.5 to 5 meters in height, and often exhibiting significant basal branching[2] .
- **Reforestation:** The planting or sowing of trees in areas where forest cover (natural forest or forest plantation) previously existed but was removed due to other land uses.
- **Secondary Vegetation:** A type of land cover that emerges after the disturbance or destruction of natural forest, either by human intervention or natural causes. This cover is characterized by primary or secondary plant succession and may include elements such as remnants of dense or fragmented natural forest, degraded areas, or shrub vegetation covering less than 30% of the minimum mapping unit.
- **Sustainable Forest Harvesting:** Silvicultural treatment consisting of the felling of trees in a way that ensures the continuity of timber resources for future generations. To be considered sustainable, forest harvesting must comply with technical and legal criteria, which vary depending on the forest type and the regulatory framework of the host country.

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1 An extension of all terms related to this methodology can be found in the Guide of Terms and Definitions COLCX.

2 IDEAM (2010). Leyenda Nacional de Coberturas de la Tierra. CORINE Methodology Land Cover adapted to Colombia Scale 1:100.000. Instituto de Hidrología, Meteorología y Estudios Ambientales. Bogotá, D. C., 72 p.

2 OBJECTIVES

Provide owners and proponents with a technical guide for the formulation and implementation of GHG Mitigation Projects (GHGMP) based on forest plantations, agroforestry systems and permanent agricultural activities.

3 SCOPE

This methodology covers relevant criteria and procedures for performing:

a) Project eligibility analysis
b) Identification, quantification and monitoring of carbon sources, sinks and reservoirs
c) Determination of the baseline scenario
d) Additionality analysis
e) Quantification of GHG removals generated by the activities
f) Guidance for leakage monitoring and control
g) Criteria for the monitoring of the GHGMP

This methodology can be applied by any type of entity, person or institution that intends to establish a project to mitigate the effects of climate change through GHG removal activities hereinafter referred to as GHGMP based on applicable activities. This methodology is applicable to Landscape Management Tools that are not located in forest areas, such as live fences, agroforestry systems and scattered trees in paddocks. In the case of forest enrichment, it can be used in conjunction with the carbon stock enhancement module (ICR) of the REDD+ methodology in its current version.

4 APPLICABLE ACTIVITIES

This methodology allows the formulation and implementation of a GHGMP in the AFOLU sector, including at least one of the following activities:

a) Timber, non-timber and/or multipurpose forest plantations
b) Agroforestry systems
c) Permanent fruit and/or agricultural crops
d) Oil palm and other palm crops

Projects implementing this methodology must consider the specific requirements established by the host country's regulations.

5 APPLICABILITY CONDITIONS

This methodology is applicable under the following conditions:

a) It is used in areas with land use rights, free from legal, administrative, or other disputes, whose documents certifying ownership, possession, or tenure reveal carbon ownership according to the legal context of each country
b) The activities listed in 4 APPLICABLE ACTIVITIES are implemented to increase vegetation cover or improve carbon storage capacity
c) Activities that comply with the regulatory and legal framework of the host country and its region
d) Plantations and/or crops that have management and harvesting plans demonstrating their production cycle and purpose

e) Areas whose land-use suitability aligns with the implemented mitigation activity (type of crop). Official zonings established by the host country must be considered. Recent ecosystem maps from official sources should be included[3].
f) When Landscape Management Tools (LMT) are implemented that incorporate forest enrichment or forest relics, the Carbon Reserve Enhancement (ICR) Module of the current REDD+ methodology may be used.

This methodology is not applicable under the following conditions:

a) Area with severe environmental risks and impacts that cannot be managed
b) Areas with applicable activities in zones that were previously secondary vegetation meeting the host country's definition of forest, natural regeneration tending toward forest or natural forest, and/or forest plantations with the same performance as the proposed activity
c) Areas in which there are plantations or ecological restoration or compensation processes established by legal obligation
d) Projects that are already registered in other GHG programs or that have some type of financing through payment for environmental services or other forms of financing for ecosystem services
e) Establishment of applicable activities in areas dominated by natural ecosystems that are periodically flooded and/or have organic soils, such as wetlands, moorlands, mangroves, among others, which have soils with a high organic matter content[4]
f) Places where the law is violated or illegal land use is encouraged
g) Areas planted with species classified as invasive

6 ELEGIBILITY

For the eligibility of the area of a GHGMP, the following criteria must be considered:

a) Areas where, ten (10) years prior to the project start date, there was no forest cover or secondary vegetation that meets the definition of forest according to each country's definitions[5]
b) Areas where land ownership is clear and there are no current or future disputes regarding ownership, distribution, or administration
c) Any type of activity on fragile or organic soils or the establishment of any activity in ecosystems classified by national regulations as strategic, protected areas, or strict nature reserves is not eligible

7 ADDITIONALITY

For the COLCX program the concept of additionality and the process for its evaluation is developed based on the Clean Development Mechanism (CDM)[6]. The mechanisms for demonstrating the additionality of a GHGMP are:

- Identification of alternative land use scenarios to GHGMP

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[3] If the project area presents edaphoclimatic differences relative to the official zoning, additional information may be provided to demonstrate its land-use suitability, as long as it is specific to the area and supported by a recognized source and endorsed by a land-use suitability expert.
[4] In such cases, the proponent must apply specific methodologies designed for these ecosystems.
[5] When no information is available, a multitemporal analysis may be carried out using satellite images with a resolution greater than 30 meters, considering each country's land-cover classification. In Colombia, this classification corresponds to the CORINE Land Cover adapted by IDEAM
[6] Consider the eligibility criteria established by the host country's regulations

- Investment Analysis and/or Barrier Analysis Selection
    - *Investment Analysis:* Determine whether the activities proposed by the GHGMP are financially feasible, without considering COLCERs funding, and that these activities are less financially attractive compared to the consistent scenarios.
    - *Barrier analysis:* This can be performed in lieu of or as an extension of the investment analysis. If this step is used, determine whether the proposed project activity faces barriers that:
        - Avoid implementation of this type of proposed project activity without revenues from the sale of GHG credits; and
        - Do not prevent the implementation of at least one of the alternative land use scenarios.
- Common practice analysis: Determines that the alternative scenarios to the project have substantial differences with the project activities.
- Comparative Emissions and Carbon Analysis: Ensures that the selected baseline scenario is the one with the highest emissions and delimits that the project generates a positive impact with respect to baseline removals, reductions and emissions.

The proponent of the mitigation initiative must demonstrate the additionality of the project through the application of the *COLCX Guide to demonstrate additionality*, so that if the mitigation initiative meets the evaluation criteria defined in the referred instrument, it may be considered additional

8 TIME AND SPACE LIMITS

The temporal and spatial limits of GHGMP allow establishing the area and temporality in which COLCERs may be generated by the removal of GHGs. All geoprocessing performed by the proponent must disclose in their attributes the area, type of coverage, year and description. The developer will determine the most appropriate attributes for managing their spatial information. Temporal data must be duly supported by accurate information that is consistent with the project situation.

8.1 Time Limits

The time limits of the project must be defined in the Project Design Document (PDD) and considering the following aspects:

8.1.1 Project Start Date

Date of establishment of the eligible GHG mitigation activity. This must be supported by documents that objectively reveal its implementation. For example, planting, commencement of management practices in the area, use of inputs, etc.

8.1.2 Retroactive period

The retroactive period for ARR projects is a maximum of five (5) years, in accordance with the guidelines provided in the current version of the certification standard.

8.2 Spatial Limits

The GHGMP must identify and delimit the areas that are subject to monitoring according to their activity. The project area corresponds to parcels or tracts of land over which the project proponent has the legal right of ownership of the land and can carry out mitigation activities. This right must be held by the proponent from the project start date and during the implementation of the GHGMP. The following criteria must be considered to identify the project area:

- Name or names of properties or areas
- Spatial delimitation of the project area. It must be presented in vector formats applicable in a GIS (e.g., shp., Geopackage, kml., among others)
- Current situation of land tenure and legal ownership of the territory
- All participants and their roles within the GHGMP. Please note the company name, document number or NIT, contact number and e-mail address

8.3 Grouped projects

For the GHGMP to be considered as grouped, an expansion area must be established that considers ecological and activity homogeneity criteria. The ecological homogeneity criteria are determined based on the similarity of the surrounding life conditions, which must have remained consistent for at least the historical eligibility period (10 years prior to the start date). The following is a list of the requirements that must be met to ensure ecological uniformity within the grouping area:

- **Similarity in land use and soil type**: soil characteristics, such as composition, use capacity and type, must be equivalent in all expansion polygons to ensure compatibility in terms of management and conservation of carbon reservoirs.
- **Elevation**: the elevation ranges present in the expansion areas must be similar to those of the original project area, which is essential to maintain consistent ecological and climatic conditions.
- **Ecosystem similarity**: the predominant ecosystems in the expansion area must coincide with those of the project area, including the dominant vegetation and other ecological aspects that ensure continuity in environmental management. To determine this similarity, structural and functional ecological criteria should be considered. In addition, species richness and diversity indices, the presence of water bodies, and other key variables can be evaluated.
- **Similar slopes**: the areas selected for expansion should have similar slopes to the original project area, to avoid significant differences in soil management.
- **Adjacent political boundaries**: expansion areas should be within adjacent political boundaries, such as neighboring municipalities or departments, to facilitate administrative management and consistency in project implementation.
- **Environmental management conditions**: expansion areas must have been subject to practices similar to those of the original project area, including afforestation, restoration or carbon reserves enhancement practices.

A maximum variation of ±15% is allowed with respect to the original conditions of the project area, thus ensuring uniformity in its implementation and results.

The project has until its first verification to include the expansion areas identified by addition; after this verification, any inclusion of new areas will require a post-registration change of the project. If areas are subtracted for various reasons, the GHGMP will not need to be revalidated, and it will be sufficient to consult COLCX about this change. Expansion areas must allocate their entire area to these same activities. This approach ensures that the practices implemented are representative and consistent with the objectives of the project, facilitating a proper evaluation of the impact and benefits generated.

It is essential that all homogeneity criteria are considered during the project's validation or first verification. The project developer must design the protocol that will guide this validation and clearly establish how each criterion is met, to allow a landholder to join a grouped project initiative.

9 APPLICABLE RESERVOIRS

The carbon reservoirs included in the different activities contemplated by this methodology will be those that can be measurable and significant with respect to the GHGMP baseline (minimum 5% to be considered). The selected reservoirs must be quantified both in the baseline scenario and in the formulation and implementation scenario. The following is a list of reservoirs that can be included in a GHGMP. For optional reservoirs, data from national or subnational GHG inventories or studies from indexed scientific journals can be used, if they apply to the climate, humidity and species implemented in the GHGMP.

Table 1 Reservoirs applicable to Afforestation, Reforestation and Revegetation activities.

Reservoir	Applicable	Description
Aboveground biomass	Yes	This corresponds to the living biomass found on the soil (stems, branches, bark and foliage). This reservoir is expected to be maintained and increased as a function of ARR activity.
Belowground biomass	Yes	Includes the living biomass of roots. Excludes fine roots less than 2 mm in diameter. Expected to be maintained in conserved forest cover or increased in areas with new vegetation cover.
Dead Wood	Opt	Comprises dead woody biomass found on the surface either standing or fallen, parts of detached wood, or exposed roots of fallen trees. Must be significant and adequately accounted for, can be monitored.
Litter	Opt	Includes all dead aboveground plant biomass less than 2 cm in diameter (leaves, branches and fruit shells). It must be justified as a significant reservoir and for its inclusion it must be possible to monitor it.
Soil Organic Carbon	Opt	It includes all organic carbon stored in the soil (including root ends smaller than 2 mm), the depth of estimation must be justified by the proponent being a minimum of 30 cm. It must be significant and adequately justified; it can be monitored[7].
Timber products	Opt	This relates to the timber products generated because of harvesting, extraction, transport and transformation of timber individuals, with the understanding that the harvesting of individuals does not generate the immediate release of stored carbon.

Where: ARR: Afforestation, Reforestation and Revegetation, Opt: Optional.

[7] Consider the current version of the soil organic carbon module.

10 EMISSION SOURCES

All emission sources must be identified in the baseline scenario, for their inclusion it must be demonstrated that they are significantly increased and consistent with eligible activity. At a minimum, the sources in Table 2, must be evaluated and, if significant, must be monitored in the project scenario.

Emission sources that account for more than 5% of the total calculated emissions between the baseline and project scenarios should be included (see Table 2). Any non-significant GHG emissions should be conservatively excluded.

For the quantification of source emissions, the equations, factors and recommendations of the IPCC[8] [9], guidelines, host country GHG inventory methodologies or GHG inventories consistent with the project area can be used.

Table 2 Emission sources in ARR activities

Source	GHG	Applicable		Description
		LB	Proj	
Forest fires	CO_2	No	No	They are quantified within carbon reserves changes
	CH_4	No	Yes	Emissions resulting from uncontrolled fires are considered emissions. Not allowed in the baseline.
	N_2O	No	Yes	
Land-Use Change	CO_2	Si	Yes	Emissions caused by changes in pre-existing carbon reservoirs due to extraction.
	CH_4	No	No	GHG other than CO_2 are not considered because burning is not allowed for the preparation of the activities.
	N_2O	No	No	
Fertilization	CO_2	No	No	All emissions from the use of synthetic fertilizers or other pre-existing amendments and in the project, scenario must be quantified.
	CH_4	No	No	
	N_2O	Opt	Yes	
Forest Harvesting	CO_2	Si	Yes	Should be considered if selective logging, forest harvesting and losses due to pests or diseases occur during project implementation. All significant emissions from agricultural and forestry machinery for harvesting should be included.
	CH_4	No	No	
	N_2O	No	No	

Where: Opt: Optional

Emissions from forest fires will be estimated in relation to the affected area, considering the corresponding biomass loss and the CH_4 and N_2O equivalencies listed below.

[8] IPCC. (2003). Orientación del IPCC sobre las buenas prácticas para UTCUTS. Available in: kutt.it/laZFfp
[9] IPCC. (2006). Directrices del IPCC de 2006 para los inventarios nacionales de gases de efecto invernadero. Agricultura, silvicultura y otros usos de la tierra. Available in: kutt.it/iLd1fY

When there is a record of biogenic fires, these emissions are calculated by establishing the ratio of methane (CH_4) and nitrous oxide (N_2O) in carbon dioxide equivalent (CO_2e) in the affected area, following the IPCC guidelines[10]: CO_2 emitted by fire episodes is not included here, as it will be quantified later in the changes in reserves.

$$\boldsymbol{ECH4\ (CO2eq)_i = ECO2eq_i * \frac{12}{44} * TE * \frac{16}{12} * PCG}\ (1)$$

Where:

$ECH4eq_i$: Equivalent CH_4 - CO_2 emission from stratum i burned.
$ECO2eq_i$: CO_2e emission factor of stratum i.
$\frac{12}{44}$: C/CO2 ratio
TE: Methane emission rate
$\frac{16}{12}$: Methane to carbon dioxide molecular ratio
PCG: Global warming potential of methane

$$\boldsymbol{EN2O(CO2eq)_i = ECO2eq_i * \frac{12}{44} * \frac{N}{C} * TE * \frac{44}{28} * PCG}(2)$$

Where:

$EN2Oeq_i$: N_2O- CO_2 emission from stratum i burned
$ECO2eq_i$: Emission factor of stratum i
$\frac{12}{44}$: C/CO2 ratio
$\frac{N}{C}$: Nitrogen-carbon ratio
TE: Methane emission rate
$\frac{44}{28}$: Molecular ratio of nitrous oxide and nitrogen
PCG: Global warming potential of methane

11 GHG EMISSION AND REMOVAL FACTORS

The emission factors[11] used for the GHGMP can be based on official data from the host country, public studies or indexed journals applicable to the area of the GHGMP. Own surveys with sufficient technical support based on the best practices are also valid. Emission factors must be measurable and verifiable to allow for monitoring and verification.

To determine the emission factors, calculations in carbon reservoirs should be considered through inventories that present an error of less than 10%, with a confidence level of 90%[12]. For the identification of these emission and/or removal sources, methodological reconstructions of the processes defined by good practices of GHG inventories or national inventories can be used, applicable to the GHGMP.

To establish emission factors, consider the following formulas, which apply to the formulation scenario (ex ante) and project scenario (ex post):

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[10] IPCC. (2003). IPCC guidelines about Good practices in AFOLU sector. Available in: https://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_files/GPG_LULUCF_FULL.pdf
[11] According to Decision 12/CP.17 of the UNFCCC, NREF/NRF must be expressed in tons of carbon dioxide equivalent per year.
[12] AR Tool 14 Version 4.1.

$$\Delta BA_{i,t} = (BA_{t1} - BA_{t2}) * \frac{44}{12} * FC \quad (3)$$

Where:

ΔBA_i: *Aboveground biomass reservoir removal or emission factor in terms of Mg* CO_2 *per hectare of stratum i, in year t*
BA_{t1}: *Aboveground biomass at initial time in terms of Mg biomass per hectare of stratum i*
BA_{t2}: *Aboveground biomass at the final time in terms of Mg biomass per hectare of stratum i*
$\frac{44}{12}$: *Carbon dioxide and carbon dioxide molecular ratio constant*
FC: *Carbon fraction in biomass*

$$\Delta BS_{i,t} = (BS_{t1} - BS_{t2}) * \frac{44}{12} * FC \quad (4)$$

Where:

ΔBS_i: *Removal or emission factor of the belowground biomass reservoir in terms of Mg* CO_2 *per hectare of stratum i, in year t*
BS_{t1}: *Belowground biomass at initial time in terms of Mg biomass per hectare of stratum i*
BS_{t2}: *Belowground biomass at the final time in terms of Mg biomass per hectare of stratum i*
$\frac{44}{12}$: *Carbon dioxide and carbon dioxide molecular ratio constant*
FC: *Carbon fraction in biomass*

$$\Delta MM_{i,t} = (MM_{t1} - MM_{t2}) * \frac{44}{12} * FC \quad (5)$$

Where:

ΔMM_i: *Removal or emission factor of the dead biomass reservoir in terms of Mg* CO_2 *per hectare of stratum i, in year t*
MM_{t1}: *Dead biomass at initial time in terms of Mg biomass per hectare of stratum i*
MM_{t2}: *Dead biomass at final time in terms of Mg of biomass per hectare of stratum i*
$\frac{44}{12}$: *Carbon dioxide and carbon dioxide molecular ratio constant*
FC: *Carbon fraction in biomass*

$$\Delta LIT_{i,t} = (LIT_{t1} - LIT_{t2}) * \frac{44}{12} * FC \quad (6)$$

Where:
ΔLIT_i: *Litter reservoir removal or emission factor in terms of Mg* CO_2 *per hectare of stratum i, in year t*
MM_{t1}: *Litter at the initial time in terms of Mg of biomass per hectare of stratum i*
MM_{t2}: *Litter at the final time in terms of Mg biomass per hectare of stratum i*
$\frac{44}{12}$: *Carbon dioxide and carbon dioxide molecular ratio constant*
FC: *Carbon fraction in biomass*

$$\Delta COS_{20i,t} = \frac{(COS_{t1} - COS_{t2})}{20} * \frac{44}{12} * FC \quad (7)$$

Where:

ΔCOS_{20i}: *Soil organic carbon reservoir removal or emission factor in terms of Mg* CO_2 *per hectare of stratum i, in year t*
ΔCOS_{t1}: *Soil organic carbon at initial time in terms of Mg carbon per hectare of layer i*
ΔCOS_{t2}: *Soil organic carbon at the end time in terms of Mg carbon per hectare of stratum i*
$\frac{44}{12}$: *Carbon dioxide and carbon dioxide molecular ratio constant*
FC: *Carbon fraction in biomass*

The emission and removal factor by stratum is presented below:

$$\boldsymbol{ECO2eq_i} = (\boldsymbol{\Delta BA_i} + \boldsymbol{\Delta BS_i} + \boldsymbol{\Delta LIT_i} + \boldsymbol{\Delta MM_i} + \boldsymbol{\Delta COS_{20i}}) \quad (8)$$

Where:

$\boldsymbol{ECO2eq_i}$: *Emissions or removals from stratum i in year t at baseline*
$\boldsymbol{\Delta BA_i}$: *Emission or removal factor from the aboveground biomass reservoir in terms of Mg per hectare*
$\boldsymbol{\Delta BS_i}$: *Emission or removal factor of the belowground biomass reservoir in terms of Mg of CO_2 per hectare*
$\boldsymbol{\Delta LIT_i}$: *Emission or removal factor of the litter reservoir in terms of Mg of CO_2 per hectare*
$\boldsymbol{\Delta MM_i}$: *Emission or removal factor of the dead biomass reservoir in terms of Mg of CO_2 per hectare*
$\boldsymbol{\Delta COS_{20i}}$: *Emission or removal factor of the organic carbon reservoir in the soil in terms of Mg of CO2 per hectare of stratum i, in year t.*

12 BASELINE SCENARIO

The baseline consists of existing GHG emission sources, sinks, and reservoirs prior to the implementation of the PMGEI, as identified in Table 1 and Table 2. To determine this, take into account the guidelines provided in **¡Error! No se encuentra el origen de la referencia. ¡Error! No se encuentra el origen de la referencia.**. Once the baseline emissions and/or removals have been defined, the scenario can be formulated, considering appropriate and reliable data sources. The emissions in the baseline scenario correspond to:

$$\boldsymbol{ECO2eq}_{It,lb} = \sum_{i=1}^{n} \boldsymbol{ECO2eq_{i,t}} \quad (9)$$

Where:

$\boldsymbol{ECO2eq}_{I,lb}$: *Total emissions from strata during the year*
$\boldsymbol{ECO2eq_{i,t}}$: *Emissions or removals from stratum i in year t*

The project owner must justify the reasons for its selection and application. The timeliness of the data must consider the current technologies used in the territory and be as recent as possible. The proponent must consider probable land uses that would exist in the absence of the mitigation initiative, justifying their presence with information appropriate to the context and host country where the initiative is established.

The selected scenario must comply with the regulatory framework, use the conservative principle for quantifying its associated emissions, and has existed for at least 10 years prior to the project start date. For this reconstruction, information from official sources can be used, prioritizing local, regional, and national information. The availability and reliability of the source must also be supported if it comes from scientific articles, technical, economic, or environmental concepts that may exist and are relevant to the project area.

13 FORMULATION SCENARIO

The following is a description of the project scenario based on assumptions and historical data called ex-ante, which is subject to validation.

13.1 Stratification

Stratification should be applied to grouped projects and to projects that differ from the variables presented below. To geographically represent the strata included within the grouped project, the areas will be georeferenced, differentiating the type of cover, the species planted, the age, and the volume of biomass.

13.1.1 Stratification variables

The variables listed must be reported for each stratum in the initiative formulation scenario.

13.1.2 Type of Coverage

The fundamental variable for stratification is the type of coverage present in the area, which must belong to one of the types of coverage of applicable activities developed by this methodology (see 4. APPLICABLE ACTIVITIES).

13.1.3 Planted species

Areas should be stratified according to the species planted within each plot to obtain specific quantification, reducing uncertainty and variations in removal for each species. In the case of mixed cover (more than one species planted within the same area), the identified stratum should be the predominant tree species within the area.

13.1.4 Age of plantation

The age of the stratum should be reported in years from its date of establishment and the time for which the quantification is carried out. The age of each stratum should be determined based on the plantation or crop establishment and management plan (EMP) and should be supported by information provided by the official plantation registry with the corresponding forestry and/or agricultural authority, when applicable.

13.1.5 Stratification Results

Once the stratification has been carried out, the following results should be presented:

a) The EMP, with which the types of cover, age and species planted were identified
b) Stratification map for the project area
c) Report of the statistical analysis generated from the data obtained in the pre-sampling, determining the categorization ranges for the final stratification, including volume.

13.2 Quantification of GHG emissions

Emissions associated with the harvesting of timber for activities related to timber or palm extraction and those derived from the use of timber products according to their useful life are described in this chapter.

13.2.1 Emissions caused by forestry, palm replanting activities, and machinery use

Emissions from the use of wood for extraction activities, the use of wood and machinery correspond to:

$$Eauf_t = Eap_t + \Delta EP_{T,t} + \Delta ETp_t \quad (10)$$

Where:

$\boldsymbol{Eauf_t}$: Emissions due to forestry and wood use in tCO_2e in year t

$\boldsymbol{Eapt}$: *Total emissions due to sustainable forest management and/or replanting of palm crops in* tCO_2e *in year t*

$\boldsymbol{\Delta EP_{T,t}}$: *Total emissions due to sustainable forest management and/or replanting of palm crops in* tCO_2e

13.2.1.1 Emissions per volume of biomass affected by harvesting activities

The determination of emissions associated with forestry activities and palm crop replanting is based on the record of individuals to be felled per year (location and dendrometric data).

An estimate of total volume and/or usable biomass must be available, derived from applicable local or regional allometric equations. These equations must consider the DBH and total height of the trees. Proprietary allometric equations designed with a minimum of 15 individuals of at least 5 diameter classes per species are acceptable.

At least the volume of biomass affected by road construction and the removal of forest individuals and/or replanting of palm crops for harvesting or management activities must be identified. When activities such as the creation of firebreaks or other types of barriers that require the removal of individuals are carried out, these must also be quantified.

$$VT_{m,t} = \sum_{i=0}^{i}(\sum_{j=1}^{j}(\sum_{l=1}^{l}(VT_{l,j,i,t}))) \ (11)$$

Where:

$\boldsymbol{VT_m}$**:** *Total volume of biomass affected by activity m, in year t*

$\boldsymbol{VT_{lj,i,t}}$**:** *Total biomass volume of tree l of species j in stratum i in* m^3*, in year t*

***l* :** *1,2,3... sequence of individual trees*

***i* :** *1,2,3 ... M strata*

***j* :** *1,2,3 ... J tree species*

***t* :** *year*

Finally, emissions from the volume used for harvesting activities are represented as:

$$Eap_t = VT_{m,t} * Db * \frac{44}{12} * FC \ (12)$$

Where:

$\boldsymbol{Eapt}$: *Total emissions due to sustainable forest management and/or replanting of palm crops in* tCO_2e *in year t*

$\boldsymbol{VT_{m,t}}$: *Total volume affected by activity m, in year t*

$\boldsymbol{Db}$**:** *Basic density of wood* (gr/cm^3)

$\frac{44}{12}$: *Molecular ratio constant of carbon dioxide and carbon*
$\boldsymbol{FC}$: *Carbon fraction in biomass for the product*
$\boldsymbol{t}$ = *year*

13.2.1.2 Emissions associated with forestry products and palm crop replanting activities

Total emissions from forest harvesting and palm crop replanting are calculated on the assumption that they are generated outside the harvesting area. These may include:

- Emission from short-lived products: Includes products that are used for activities associated with the project area, whose emission takes place in the same year of harvesting. E.g., fuel wood, harvested residues.
- Emission from products with a moderate to a long life: Includes products whose emission occurs in periods greater than 1 year and up to 100 years, depending on their useful life. E.g. paper, furniture and structural wood products.

The residues and remnants left on site can be considered as contributions of dead matter and leaf litter. Emissions from timber harvesting and replanting are calculated using the following formulae[13]:

$$\Delta EP_{T,t} = E_{p,t} + E_{s,t} (13)$$

Where:

$\boldsymbol{\Delta EP_{T,t}}$: *Total emissions due to sustainable forest management and/or replanting of palm crops in* tCO_2e
$\boldsymbol{E_{p,t}}$: *Emissions from fast-release products, in* $MgCO_2$ *equivalent, in year t*
$\boldsymbol{E_{s,t}}$: *Emissions due to moderate to slow-release products, in* $MgCO_2$ *equivalent, in year t*

Given the differences in GHG release associated with timber products, these should be calculated considering three categories[14]. The first category is that which is broken down into the first three years of harvesting. This is calculated as:

$$E_{p,t} = Vpt * Db * \frac{44}{12} * FC \quad (14)$$

Where:

$\boldsymbol{E_{p,t}}$: *Emissions due to quick release products, in Mg* CO_2 *equivalent, in year t*
$\boldsymbol{Vp_t}$: *Volume of short-lived wood products (1 year), in year t*
$\boldsymbol{Db}$: *Basic density of wood (gr/cm*^{3}*)*
$\boldsymbol{\frac{44}{12}}$: *Carbon dioxide and carbon dioxide molecular ratio constant*
$\boldsymbol{FC}$: *Carbon fraction in biomass for the product*
$\boldsymbol{t}$ = *year*

[13] Refer to Tables 12.4 and 12.5 of the IPCC guidelines on harvested wood products (HWP) for volume determination https://www.ipcc-nggip.iges.or.jp/public/2006gl/spanish/pdf/4_Volume4/V4_12_Ch12_HWP.pdf.
[14] Define the useful life for each type of product identified and quantify the corresponding progressive emissions based on this. Consider the IPCC clarifications on harvested wood products.

The second category is wood that has a life span of 2 to 100 years. This category is estimated on a linear decomposition of 20 years.

$$E_{s,t} = Vst * Db * \frac{44}{12} * FC \ (15)$$

Est: *Emissions due to moderate release products in Mg CO_2 equivalent, in year t*
Vst: *Wood volume of medium-lived products (2 to 100 years), based on 20-year linear decomposition, in year t*
Db*: Basic density of wood (gr/cm^3)*
$\frac{44}{12}$***:*** *Carbon dioxide and carbon dioxide molecular ratio constant*
FC: *Carbon fraction in biomass for the product*
t *= year*

For the third category, corresponding to those products with a life of more than 100 years, it is assumed that their carbon reserves are permanently conserved.

13.2.1.3 Emissions from the use of machinery harvesting and processing in timber

The machines used for harvesting and processing wood must be identified, considering the volume of fuel, the type, and the corresponding emission factor for each machine and/or means of transport. This is calculated as follows:

$$\Delta ETp_t = E_{harvesting} + E_{minor\ transport} + E_{major\ transport} + E_{processing} (96)$$

ΔETp***:*** *Emissions due to activities associated with harvesting machinery in Mg CO_2 equivalent, in year t*
$E_{harvesting}$***:*** *Total emissions due to the use of machinery associated with harvesting in Mg CO_2 equivalent, in year t*
$E_{major\ transport}$***:*** *Total emissions due to minor timber transport in Mg CO_2 equivalent; in year t*
$E_{processing}$***:*** *Emissions due to electricity consumption at the sawmill in Mg CO_2 equivalent, in year t*

For the calculation of emission factors associated with CO_2, CH_4 and N_2O related to fossil fuels, IPCC guidelines[15] can be used. For the electricity used, use the emission factors of the host country when available.

13.2.2 Leakages

The project proponent must verify the guidelines on leakages described in the certification standard. For projects developed under this methodology, the leakages considered are classified as follows[16]:

1. Displacement of activities: This occurs when pre-existing productive activities in the project area migrate to another location because of the implementation of project activities. These leakages are related to the relocation of an economic activity from scenarios without the project to scenarios with the project.

[15] IPCC. 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories. https://www.ipcc-nggip.iges.or.jp/public/2006gl/spanish/pdf/2_Volume2/V2_3_Ch3_Mobile_Combustion.pdf
[16] Schwarze, *et al.* (2002). Understanding and managing leakage in forest-based greenhouse-gas-mitigation projects. The Royal Society.

2. Market leakage: This occurs when a factor alters the supply, demand, or equilibrium price of goods and services that were previously available in the area or derived from activities carried out on the site, causing an increase in emissions. For example, a forest conservation project may reduce the availability of local timber, leading to increased pressure on this resource in other natural areas. These leakages are based on the alteration of a price or commercial dynamic.
3. Ecological leakage: Change in emission flows at the ecosystem level in areas adjacent to the project. Ecological leakage is positive when project activities generate a positive ecological impact in surrounding areas, and negative when they generate negative impacts, in any case resulting in carbon loss in the project and underlying areas.

Leakages associated with life cycle emissions are not considered in this chapter; those related to the use and utilization of wood products are reported in accordance with section 13.2.1 and 13.2.1.3.

13.2.2.1 Leakage quantification

The following actions should be considered in the process of quantifying leakages:

1. Identification of leakage sources according to the categories listed
2. Determination of the area where these leakages occur
3. Quantification of emissions associated with identified leakages

The quantification of emissions from leakages is determined by their type. In accordance with the above, leakages are quantified as follows:

- <u>Leakage due to displacement of productive activity</u>

$$Efda_t = Ad \times \Delta AP_i \ (17)$$

Where:

> **$Efda_t$**: *Emissions from displacement of productive activities in the leakage area in tCO_2 equivalent; in year t.*
> ***Ad***: *Leakage area (Displaced area) (Hectares)*
> **ΔAP_i**: Emissions factor of displaced productive activity i (tCO_2e/productive unit – hectare)[17]

Estimated emissions from the displacement of productive activity must be extrapolated to the project's time horizon or until it is demonstrated that leakage has occurred in the new area, considering that, although the displacement is unique, the development of these productive activities will be long-lasting.

When changes in land use occur, the emissions associated with these changes and the corresponding carbon losses must be quantified. E.g. The arrival of a forestry project displaces livestock farming to areas of natural forest, causing a loss in these carbon reserves. In this case:

$$Efcu_t = Ad * ECO2eq \ (18)$$

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[17] The calculation of emission factors in tCO_2e must be carried out for the different gases with the most up-to-date global warming potential. For livestock activities, emission factors from the FAO's GLEAM tool can be used.

Where:

> ***$Efcu_t$:*** *Emissions from land use change in the leakage area in tCO_2 equivalent; in year t*
> ***Ad***: *Leakage area (displaced area) (hectares)*
> ***$ECO2eq$***: *Emission factor of the reservoir affected by the changes generated (tCO_2e/hectare)*

- Market leakages

The quantification of market leakage can be carried out:

a) With project-specific market analysis information (supply and demand) for the area or region where the project is located
b) Based on standard leakage rates from official sources or literature for different production activities.

$$Efm_t = Pe * And * \Delta AP_i * Tf \ (19)$$

Where:

> ***Efm_t***: *Market leakage emissions in tCO_2 equivalent; in year t*
> ***Pe***: *Lost or reduced production, i.e., what is no longer produced due to the arrival of the project (Production unit P.E. kg/ha-year).*
> ***And***: *Area used to compensate for this loss in a location other than the leakage area.*
> ***ΔAP_i:*** *Emissions factor for productive activity i (tCO_2e/productive unit-ha)*
> ***Tf***: *Market leakage rate as a percentage. Equivalent to the percentage of production that will be replaced by the market in another area*[18].

When activity displacement occurs across the entire project area, it is assumed that no market leakage is generated, and vice versa. However, if activity-shift leakage displaces only a fraction of the area dedicated to that activity-under the same productivity assumptions -the remaining area is considered to correspond to market leakage. For example: If 100 hectares are dedicated to cattle ranching and 20 hectares are displaced while maintaining the same productivity, this suggests that the lost productivity on the remaining 80 hectares is absorbed by the market.

- Environmental leakages

Ecological leakages are biological and ecosystemic environmental impacts resulting from the implementation of the project. Therefore, they must be identified in the environmental impact analysis and, if they generate carbon sink losses or emissions, they must be quantified.

$$Efe_t = Ad * ECO2eq \ (20)$$

Where:

> ***Efe_t***: *Emissions from ecological impacts that generate carbon losses in the leakage area in tCO_2 equivalent; in year t*

[18] You can assume a default leakage rate of 70% under a conservative approach. In other words, it is assumed that 70% of that loss in production or supply is offset by the market outside the displaced area.

Ad: *Leakage area (impacted area) (hectares)*
$ECO2eq$: *Emission factor of the reservoir affected by the impacts generated (tCO_2e/hectare)*

Thus, total emissions in the leakage area will correspond to the sum of emissions from activity displacement, land use change, market, and ecological emissions. Any leakage corresponding to zero must be justified in accordance with the above guidelines.

$$ETAF_t = Efda_t + Efcu_t + Efm_t + Efe_t \quad (21)$$

Where:

$ETAF_t$: *Total emissions in the leakage area in tCO_2 equivalent; in year t.*
$Efda_t$: *Emissions from displacement of productive activities in the leakage area in tCO_2 equivalent; in year t*
$Efcu_t$: *Emissions from changes in carbon reservoirs in the leakage area in tCO_2 equivalent; in year t*
Efm_t: *Market leakage emissions in tCO_2 equivalent; in year t*
Efe_t: *Emissions from ecological leakages in tCO_2 equivalent; in year t*

The project proponent must discount leakages in their project scenario for the reporting period. In projects of this type, it is estimated that leakages occur in the first five years, which is why it is assumed that leakages due to displacement of activities are zero after this period, if the areas are the same. If the project area increases, a leakage analysis must be carried out for the new area and the corresponding discounts applied, if applicable, for the same period (5 years)

13.2.2.2 Leakage management

The proponent must describe in their proposal actions for leakage management, where it can be considered[19]:

- Delimitation of sites to prevent leakages in strategic ecosystems, such as wetlands, marshes, moors, nature reserves, etc
- When applicable, define specific areas where the management of leakages generated will take place; these correspond to the leakage management area
- Develop mitigation activities both within the project and in leakage management areas that reduce the movement of emissions outside the project boundary
- Create activities that compensate for the losses perceived by the actors involved that would lead them to generate leakages, e.g., create agroforestry systems that supply the demand for food and/or firewood for cooking
- Establish leakage agreements that limit or condition leakage generation in areas surrounding project activities

13.2.2.3 Leakage monitoring

The proponent must monitor the leakages considered for analysis. Thus, the monitoring report must include the activities that generate leakages, the supervision mechanisms, the person responsible for monitoring, and the results obtained for each verification period.

[19] Schwarze, *et al*. (2002). Understanding and managing leakage in forest-based greenhouse-gas-mitigation projects. The Royal Society.

The use of remote sensors, sampling in areas outside the project, analysis of secondary variables, key indicators[20] or correlations, among others, is valid for leakage monitoring, justifying the feasibility of their selection. Consider regional or national analyses or reports when necessary, understanding the expanded effect that leakages can have and the difficulties of accessing all areas.

Similarly, they must be constantly monitored throughout the project's time horizon, reporting their existence or absence.

13.3 Calculation of projected removals

The formulation scenario, based on projections derived from modeling increases in GHG removals, may be supported by secondary studies or proprietary studies demonstrating the upward trend in reservoirs. This multi-temporal modeling by crop type should be performed for the project accreditation period.

In the following equation, replace the efficiency coefficient (EF) based on the activities generated by the proponent for the performance of the reservoirs. Removals and the factor $(1 + Ef)$ must be multiplied year by year according to the total projected removals. The proponent may apply the efficiency coefficient in a justified manner or use average annual increase data to model the average growth of carbon reservoirs, justifying the choice made.

$$\Delta FRR_{ACTUAL,t} = (\Delta CP_{T,t} - ECO2eq_{It,lb} - Eauf_t - \Delta Eaft_{,t})(1 + Ef) \ (22)$$

Where:

$\boldsymbol{\Delta FRR_{ACTUAL,t}}$ *(tCO_2e): Projected net CO_2 removals, by sinks at year t*
$\boldsymbol{\Delta CP_{T,t}}$ *(tCO_2e): Projected carbon removals in sinks at year t* [21]
$\boldsymbol{ECO2eq_{I,lb}}$: *Total emissions from strata in year t*
$\boldsymbol{Eauf_t}$: Emissions due to forestry and wood use in tCO_2e in year t
$\boldsymbol{\Delta EafT_t}$: *Total emissions in the leakage area in tCO_2e in year t*
$\boldsymbol{Ef}$: *Project efficiency coefficient*

In any case, modeling of changes in carbon stocks must be performed for each applicable reservoir, considering the following equation:

$$\Delta CP_{T,t} = (\Delta BA_{i,t} + \Delta BS_{i,t} + \Delta LIT_{i,t} + \Delta MM_{i,t} + \Delta COS_{20i,t}) \ (23)$$

Where:

$\boldsymbol{\Delta CP_{T,t}}$: *Projected carbon removals in reservoirs at year t*
$\boldsymbol{\Delta BA_{i,t}}$: *Aboveground biomass reservoir emission factor in terms of Mg per hectare, year t*
$\boldsymbol{\Delta BS_{i,t}}$: *Belowground biomass reservoir emission factor in terms of Mg CO_2 per hectare, year t*
$\boldsymbol{\Delta LIT_{i,t}}$: *Emission factor of the leaf litter reservoir in terms of Mg CO_2 per hectare, in year t*
$\boldsymbol{\Delta MM_{i,t}}$: *Emission factor of the dead biomass reservoir in terms of Mg CO_2 per hectare, year t*
$\boldsymbol{\Delta COS_{20i,t}}$: *20-year soil organic carbon reservoir emission factor in terms of Mg CO_2 per hectare, in year t*

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[20] It is valid to use the traffic light approach, where: Green: No signs of leakage - no action required; Yellow: Potential risk - analysis required; Red: Strong evidence of leakage - the project must correct or take responsibility.
[21] *Changes in the reservoirs, as well as their uncertainty, should be applied following the guidelines of A/R TOOL 14. (See* ar-am-tool-14-v4.2.pdf (unfccc.int)).

Once the estimate of the projected increase in removals in the formulation scenario has been made, the COLCERs are estimated using the following formulae:

- For ARR activities:

$$COLCERSDef_t \;\; = \Delta FRR_{ACTUAL,t} * (1 - \%RNP) \;\; (24)$$

Where:

$\boldsymbol{COLCERS_{FRR}}$**:** *Projected certificates that are attributable to ARR activities, in year t.*
$\Delta\boldsymbol{FRR}_{ACTUAL,t}$ *(tCO_2e): Projected net CO_2 removals by sinks at year t*

$\%\boldsymbol{RNP}$**:** *Risk of non-permanence*

14 IMPLEMENTATION SCENARIO

The calculations for the implementation scenario are the same as for the formulation scenario, except for the values for each carbon reservoir.

- For aboveground biomass and the calculation of $\Delta CP_{T,t}$ the Increase of Carbon Reserves (ICR) module and the methods described for the determination of carbon assets should be taken as a reference. In addition, from the CDM AR-TOOL14 tool.
- In the case of the variable $\Delta EP_{T,t}$, the proponent must keep a GHG inventory of all associated variables, including emissions caused by the impact on GHG reservoirs, direct emissions due to forest harvesting and/or renewal of palm cultivation, and emissions due to the use of machinery.
- Emissions should follow the same equations of the formulation scenario, applying the actual values. These should be supported with fuel inventories, technical specifications of the machinery, among others.
- For reservoirs other than aboveground biomass, methodologies endorsed by the CDM or from national GHG inventories, research institutes or scientific methods published in indexed scientific journals can be used.

15 MONITORING PLAN

The GHGMP proponent must monitor the activities implemented in the ARR initiative from the start date, generating an adequate follow-up of the GHG reductions and/or removals achieved because of its performance. The monitoring plan must define as a minimum the evaluation of variables associated with:

- Increase in carbon reservoirs
- GHG emissions associated with the activity
- Emission leakage (when applicable)
- Reversion and non-permanence risks
- Generation of no net harm and socio-environmental safeguards
- Contribution to the Sustainable Development Goals (SDG)

15.1 Data and parameters to monitor

This section presents the factors to be considered by the proponent in the reporting and monitoring of each related variable, covering the categories listed below.

Data / Parameter	Measured parameter (e.g. Area)
Unit of measure	(e.g. Hectare – ha)
Value applied	Indicate the value used in the analysis
Description	Characteristics of the measured parameter
Frequency of monitoring	Measurement timing
Responsible for monitoring	Actor related to parameter reporting
Source of information	Indicate where the information will be obtained from
Quality control and quality assurance activities	Mechanisms to ensure traceability and consistency of the information used
Additional information	Additional data explaining the parameter used

A monitoring plan should be proposed, including a general description of its content, follow-up mechanisms, data to be collected, data collection mechanisms, procedures to ensure the management and quality of the information.

To ensure traceability of the GHGMP, all information used, calculated and generated by the developer or reference must be documented and archived during the GHGMP crediting period under the responsibility of the proponent.

All mandatory monitoring variables on carbon sources, sinks and reservoirs must be verified at least every monitoring period.

15.2 Monitoring mechanisms

Information on increases in aboveground biomass can be monitored through on-site data collection (e.g., forest inventories, censuses, sampling, etc.) or a combination of this with digital coverage monitoring, covering the thresholds of certainty and accuracy required by the methodology.

For reservoirs other than aboveground biomass, the program's methodologies and modules may be used whenever applicable, as well as guidelines endorsed by the CDM or national GHG inventories, research institutes, or scientific methods published in indexed scientific journals.

16 REVERSION AND NON-PERMANENCE RISKS MANANGEMENT

The analysis of non-permanence and reversal risks consists of monitoring strategic indicators that allow identifying the integrity of carbon reservoirs in the long term. The non-permanence risk analysis must be developed in accordance with the *COLCX Guide for the identification of non-permanence risks* in its most updated version.

17 UNCERTAINTY

The calculation of uncertainties will be based on the parameters established in the *Guide for the identification of non-permanence risks* which details the general procedure for their estimation, thresholds, and other considerations, based on the guidelines defined by the IPCC. This estimation must be carried out for each carbon reservoir in forest lands[22] and for the project activities that generate emissions or removals (activity data)[23].

18 CONTRIBUTION TO THE SDG

The project proponent must indicate how the project activities contribute to the achievement of the Sustainable Development Goals (SDG) targets proposed by the 2030 Agenda. If the country where the initiative is developed has an adaptation of the SDG targets, the proponent may demonstrate its alignment with the specific objectives of the territory.

The project must consider the criteria and guidelines defined by the *COLCX Guide for Reporting Contributions to the SDGs* in its most updated version.

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History of the document

Version	*Date*	*Description*
1.0	August 10, 2023	Development initial version
2.0	July 22, 2024	Adjustments to the version 1.0
3.0	May 08, 2025	Adjustments to the version 2.0
3.1	October 21, 2025	Adjustments to formula and acronym numbering, stratification variables, emissions due to forest use. The uncertainty number is modified by moving the calculation requirements to the *Guide for the identification of non-permanence risks.* The quantification of leakages in the activity (section 13.2.2.) is included, establishing the requirements and considerations for their quantification. This version is applicable to initiatives that are in the formulation and design stage as of the date of official publication. Its transition uses the guidelines defined in the program's methodological adoption standard in its current version.

22 https://www.ipcc-nggip.iges.or.jp/public/2006gl/spanish/pdf/4_Volume4/V4_04_Ch4_Forest_Land.pdf
23 https://www.ipcc-nggip.iges.or.jp/public/2006gl/spanish/pdf/1_Volume1/V1_3_Ch3_Uncertainties.pdf