METHODOLOGICAL DOCUMENT
AFOLU SECTOR

Quantification of GHG Emission Reductions or GHG Removals from Sectoral GHG Mitigation Projects

ACTIVITIES THAT PREVENT LAND USE CHANGE IN HIGH MOUNTAIN ECOSYSTEMS

PROCLIMA®

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Acronyms and abbreviations

AB	Aboveground biomass
AFOLU	Agriculture, Silviculture and Other Land Uses
ANLA	National Authority of Environmental Licenses (Autoridad Nacional de Licencias Ambientales)
BB	Belowground biomass
CFTB	Carbon fraction in the total biomass
CF	Carbon fraction in the dry matter
CNVC	Change in the area with natural vegetation cover
CH_4	Methane
CO_2	Carbon dioxide
CO_{2e}	Carbon dioxide equivalent
FAO	Food and Agriculture Organization of the United Nations
GHG	Greenhouse Gases
GIS	Geographical Information System
HME	High Mountain Ecosystems
IAvH	Alexander von Humboldt Institute for Research on Biological Resources (Instituto de Investigación de Recursos Biológicos Alexander von Humboldt)
ICONTEC	Colombian Institute of Technical Standards and Certification (Instituto Colombiano de Normas Técnicas y Certificación)
IDEAM	Institute of Hydrology, Meteorology and Environmental Studies (Instituto de Hidrología, Meteorología y Estudios Ambientales)
IPCC	Intergovernmental Panel on Climate Change
N_2O	Nitrous oxide
NTC	Colombian Technical Norm (Norma Técnica Colombiana)
QA/QC	Quality Control/Assurance Control
REDD+	Reducing Emissions from Deforestation and forest Degradation, plus the sustainable management of forests, and the conservation and enhancement of forest carbon stocks
SMByC	Forest and carbon monitoring system (Sistema de monitoreo de bosques y carbono)
SOC	Soil Organic Carbon
TB	Total biomass
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
VCC	Verified Carbon Credits

1 Introduction

High mountain ecosystems are found in the Andean mountain. Their altitude is over 2700 +/- 100 m. Its origin is glacial and periglacial modeling along with volcanic action in the central mountain range and the Colombian Massif[1].

According to FAO, "*ecosystems in the mountains are more fragile than those lowlands. Increasing demand for water and other natural resources, the consequences of global climate change, the growth of tourism, and the pressures from industry, mining and agriculture, all threaten the extraordinary web of life that mountains support and the globally important environmental services that mountains provide*"[2].

Therefore, it is recognized that high mountain ecosystems are under increasing pressure from anthropogenic activities despite their legitimate ecological and socioeconomic value. It is why in its sustainable development agenda, the UN determines actions for the conservation of mountain ecosystems, such as: "By *2030, ensure the conservation of mountain ecosystems, including their biological diversity, in order to enhance their capacity to provide essential benefits for sustainable development*"[3].

Therefore, actions that contemplate an integrated landscape approach, including productive reconversion or substitution towards more sustainable activities and ecological restoration in high mountain ecosystems, can provide economic incentives for conservation and the strengthening of local governance.

Consequently, activities that avoid land use change in high mountain ecosystems are an option for sectoral GHG mitigation projects in the AFOLU sector, framed within the PROCLIMA Certification and Registration Program.

This methodological document focuses on activities that avoid natural vegetation cover in paramos change to other land uses. Activities that avoid deforestation and forest degradation in high mountain ecosystems (HME) shall apply the methodological document "AFOLU sector - Quantification of GHG Emissions from REDD+ Projects."

Ecological restoration activities, linked to reducing land use changes in HMEs, should follow the AFOLU sector methodology document "GHG Emission Reductions or Removals from Sectoral Mitigation Projects. GHG Removal Activities"[4].

[1] Sarmiento, C., Cadena, C., Sarmiento, M., Zapata, J. & León, O. 2013. Aportes a la conservación estratégica de los páramos de Colombia: actualización de la cartografía de los complejos de paramo a escala 1:100.000. Bogotá: Instituto de Investigación de Recursos Biológicos Alexander von Humboldt. Bogotá, D.C. Colombia.
[2] FAO and the Post-2015 Development Agenda (15.4)
[3] United Nations. General Assembly. 2015. Resolution adopted by the General Assembly on 25 September 2015. 70/1. Seventieth session, Agenda items 15 and 116. Transforming our world: the 2030 Agenda for Sustainable Development. 21 October 2015. 35 p.
[4] Complying with the applicability conditions of said methodology, excluding the one related to organic soils (Section 5, (c)).

This document provides sectoral mitigation project holders with best practices related to procedures, models, parameters, and data to quantify GHG emission reductions or removals attributable to activities that avoid land use change in paramo ecosystems.

The methodology contemplates aspects related to the definition of activities that avoid land use change in high mountain ecosystems, spatial and temporal limits, causes and agents of land use change, identification of the baseline scenario and additionality, management of uncertainty in the quantification of baseline and mitigation results, as well as risk and leakage and non-permanence management.

1.1 Objectives

The objectives of this methodological document (hereinafter referred to as this Methodology) are:

(a) provide requirements for the quantification of GHG emission reductions or removals from activities that avoid land use change in high mountain ecosystems;

(b) provide methodological requirements for baseline identification of projects that avoid land use change in high mountain ecosystems;

(c) provide methodological requirements to demonstrate additionality of projects that avoid land use changes in high mountain ecosystems;

(d) describe the requirements for monitoring and follow-up of project activities that avoid land use change in high mountain ecosystems.

2 Version y and validity

This document constitutes Version 1.1. March 3, 2021.

This version may be updated from time to time and intended users should ensure that they use the most recent document version.

3 Scope

This methodological document corresponds to a methodology for baseline, quantification of GHG emission reductions or removals, and monitoring sectoral mitigation projects in the AFOLU sector, including leakage management and non-permanence considerations. This Methodology is limited to project activities that generate GHG emission reductions or removals by avoiding land use changes in high mountain ecosystems.

This Methodology should be used by projects in high mountain ecosystems to be certified and registered with the "Certification and Registration Program for GHG Mitigation Initiatives and other Greenhouse Gas Projects." PROCLIMA Program.

The holder of an initiative may propose activities that involve the use of different methodologies or modules developed by ProClima, as long as the requirements contained in the methodologies and modules, applied together, are met.

4 Applicability conditions

This Methodology is applicable under the following conditions:

(a) project activities prevent unplanned land use change in high mountain ecosystems;

(b) the causes of land use changes identified include expansion of the agricultural frontier, timber extraction, and mining activity;

(c) the GHG removal activities proposed by the Project to avoid land use change do not include drainage;

(d) the ground disturbance attributable to the project activity does not cover more than 10% of the surface area within the project boundaries[5];

(e) carbon stocks in soil organic matter, litter, and deadwood are likely to decrease, or remain stable, in the absence of project activities, i.e., relative to the baseline scenario;

(f) quantification of GHGs other than CO_2 is included in quantifying emissions caused by fires during the monitoring period.

5 Normative references

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

(a) PROCLIMA Program. Certification and Registration Program for GHG Mitigation Initiatives and other Greenhouse Gas Projects, in its most recent version;

(b) the national legislation in force, related to sectorial GHG mitigation projects, or that which modifies or updates it;

(c) Resolution 471 of 2020, or the one that modifies or updates it;

[5] The condition is related to the preparation of the soil for the activities proposed by the owner of the initiative to avoid land use change. Depending on the management practices, soil disturbance may or may not occur. Therefore, soil disturbance generated by GHG removal activities cannot exceed 10%.

(d) Resolution 1447/2018, or such resolution that amends or updates it;

(e) the 2006 and 2019 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 4. Agriculture, forestry, and other land uses;

(f) the guidelines, other orientations, and guides defined by PROCLIMA, within the projects' scope in the AFOLU sector.

6 Terms and definitions

Additionality

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

Those GHG emission reductions or removals that the holder of the GHG mitigation initiative demonstrates that had not occurred in the absence of the GHG mitigation initiative are considered additional, considering the provisions of section 8 of this document

Agents causing the land use change

Individuals, social groups, public or private institutions that, influenced or motivated by one or more underlying direct causes, decide to convert natural forests or vegetation cover to other land cover and land uses.

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.

Baseline scenario

The baseline or reference scenario represents the sum of variations in carbon stocks, included within project boundaries, in the absence of the initiative's activities.

Carbon fraction

Tons of carbon per ton of dry biomass.

Carbon pool

A compartment in which carbon stock changes occur in terrestrial ecosystems (above-ground biomass, below-ground 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.

Direct causes of land use change

Direct causes are related to human activities that directly affect forests or natural vegetation cover. These causes include factors that operate at the local scale and are different from the initial structural or systemic conditions. They originate in land use and function through natural resources use or natural cover elimination to make way for other land uses.

Eligible areas

Eligible areas are located in the paramos complex delimited by the IAvH at a scale of 1:100,000[6]. In turn, areas with natural vegetation cover on the reference dates established by the PROCLIMA Program are eligible. That is, areas within the Project's geographical limits correspond to the natural vegetation cover category, at the beginning of the project activities and at least five years prior to the project start date.

Forest

Land mainly covered by trees which might contain shrubs, palms, guaduas, grass, and vines, in 190 which tree cover predominates with a minimum canopy density of 30%, a minimum canopy height 191 (in situ) of 5 meters at the time of identification, and a minimum area of 1.0 ha. Tree covers from commercial forest plantations, palm crops, and planted trees for agricultural production are excluded.

This definition is in line with the criteria defined by the UNFCCC in decision 11/CP.7, the definition adopted by Colombia under the Kyoto Protocol (MAVDT, 2002), the definition of forest cover used in National Greenhouse Gas Inventory estimations and reports, and the definition included in the Colombian legend adaptation of the CORINE Land Cover (CLC) methodology.

High mountain ecosystems [7]

The Colombian high mountain is defined as the geographic space corresponding to the altitudinal culminations of the Andean mountain ranges from 2700 +/- 100 m, in whose modeling have intervened processes of glacial and peri-glacial origin (current and inherited), along with the volcanic action in the Cordillera Central and the Colombian Massif.

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[6] Consult in Sistema de Información Ambiental de Colombia la capa *Complejo de paramos a escala 1:100.000* generada por el IAvH. The Paramo Complex layer at a scale of 1:100,000 generated by the IavH.

[7] Sarmiento, C., Cadena, C., Sarmiento, M., Zapata, J. & León, O. 2013. Aportes a la conservación estratégica de los páramos de Colombia: actualización de la cartografía de los complejos de paramo a escala 1:100.000. Bogotá: Instituto de Investigación de Recursos Biológicos Alexander von Humboldt. Bogotá, D.C. Colombia.

This zone is characterized by volcanoes, glaciers, high humidity-receiving watersheds, lagoon systems, and moorlands. Besides, it has the highest density of water bodies compared to other areas of the country, except for the rivers' flood zones.

Land use change

Changes in land use that constitute loss of natural cover. Changes generated by anthropic activities result in converting forests, or natural vegetation cover to other land uses.

When the land use change is from forest cover to another type of cover, it is called deforestation.

Leakage

Potential emissions that would occur outside the project boundary from GHG mitigation initiative activities. Leakage means the net change in anthropogenic emissions by sources of greenhouse gases (GHG) that occurs outside the project boundary, measurable and attributable to the project activity.

Natural vegetation cover, other than forest

It comprises natural vegetation covers and natural succession products, whose growth habit is shrubby and herbaceous, developed on different substrates and altitudinal floors, with little or no anthropogenic intervention. For the CORINE Land Cover legend adapted for Colombia, this class includes other cover types such as areas covered by mainly shrubby vegetation with an irregular canopy like shrubs, palms, vines, and low vegetation.

Non-forest

Land that has never had a forest cover 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.

Organic soils

According to FAO (definition adopted by IPCC)[8], organic 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:

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[8] Hiraishi, Takahiko, et al. "2013 supplement to the 2006 IPCC guidelines for national greenhouse gas inventories: Wetlands." *IPCC, Switzerland* (2014).

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 must 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 has either:

   a) At least 12 percent organic carbon by weight (i.e., about 20 percent organic matter) if the soils have no clay;

   b) At least 18 percent organic carbon by weight (i.e., about 30 percent organic matter) if the soils have 60% or more clay; or

   c) An intermediate proportional amount of organic carbon for intermediate amounts of clay.

Paramo[9][10]

High mountain ecosystem. It is located between the upper limit of the Andean forest and, sometimes, with a lower limit of glaciers or perpetual snow, in which herbaceous and grassy vegetation dominates, often "*frailejones*". It may have low and shrubby forest formations and wetlands such as rivers, streams, creeks, peat bogs, swamps, lakes, and lagoons.

It comprises three strips in ascending order: the sub-paramo, the proper paramo, and the super paramo. The altitudinal limits of these ecosystems vary between mountain ranges due to local orographic and climatic factors. The anthropic intervention has also altered the paramo's altitudinal distribution, so this definition includes paramos altered by humans.

Sub-paramo or low paramo: The lower strip of the paramo that follows that occupied by the arboreal vegetation of the Andean forest of the region. It is characterized by the predominance of chuscales, shrub vegetation, and low Andean forests.

Paramo proper: Intermediate strip of the paramo characterized mainly by dominant vegetation of grasslands and different species of *frailejones*.

Super paramo or high paramo: Upper band of the paramo characterized by low vegetation cover and different bare soil surface degrees.

[9] Resolución No. 0769 del 05 de agosto de 2002 (MAVDT).
[10] Consult in Sistema de Información Ambiental de Colombia la capa *Complejo de paramos a escala 1:100.000* generada por el IAvH.

Azonal paramo: *Parámos* located in atypical zones according to local and extreme edaphic and climatic conditions, characterized by the vegetation of *paramuno* type.

Permanence

It is the condition resulting from the project activities whereby the system implemented within its limits extends continuously, and over time, removes GHG from the atmosphere.

Project start date

The date on which activities result in actual GHG emission reductions or removals begin. For projects applying this Methodology, the start date corresponds to how the implementation of project activities directly related to reducing land use changes begins.

REDD+

It is an international mitigation mechanism framed in the decisions of the CMNUCC, 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

It is a type of GHG mitigation project that implements REDD+ activities, covers an accurately delimited subnational geographic area, and is privately or publicly owned, the latter within the framework of the functions and competencies assigned by the Law. These initiatives demonstrate their mitigation results within the context of compliance with the goals indicated in the Comprehensive Deforestation Control and Forest Management Strategy and the national climate change objectives established under the UNFCCC.

Reference region

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

Related GHG source, sink, or pool

Source, sink, or pool of GHGs with flows of energy or materials inward, outward, or within the Project.

Restoration

According to the National Plan for Ecological Restoration (MADS, 2015)[47], restoration is an interdisciplinary strategy, which articulates scientific knowledge to respond to management processes and ecosystem management to the needs of restoring degraded ecosystems and prevent future damage.

The restoration includes interventions such as (a) ecological restoration, (b) environmental rehabilitation, and (c) environmental recovery.

Ecological restoration consists of restoring the degraded ecosystem to a condition like the pre-disturbance ecosystem concerning its composition, structure, and functioning. Besides, the resulting ecosystem must be a self-sustaining system and must guarantee species conservation, the ecosystem in general, and most of its goods and services.

Ecological rehabilitation aims to bring the degraded system to a system similar or not to the pre-disturbance system, which must be self-sustaining, preserve some species, and provide some eco-systemic services.

Ecological recovery aims to recover some eco-systemic services of social interest. Generally, the resulting ecosystems are not self-sustaining and do not resemble the pre-disturbance system.

Underlying causes of land use change

Underlying causes are factors that reinforce the direct causes. 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 land use changes occur.

Wetlands

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 will be restricted to wetlands where the water table is artificially changed (e.g., drained or raised) or those created through human activity*"[11].

[11] https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_07_Ch7_Wetlands.pdf

7 Project boundaries

7.1 Spatial limits

7.1.1 Project area

The project holder must demonstrate that the areas within the Project's geographical boundaries are included in the moorland complex delimited by the IAvH and correspond to the category of natural vegetation cover at the beginning of the project activities and five years prior to the project start date.

The holders of the GHG mitigation initiative may add areas to the Project under the following conditions:

(a) The project holder shall identify the project expansion area during the validation process and define the criteria for adding new areas;

(b) The default criteria that a new area must meet to be added to the Project are:

i) Comply with the guidelines of the Certification and Registration Program for GHG Mitigation Initiatives and other Greenhouse Gas Projects, in its most recent version;

ii) Comply with all the provisions of the AFOLU SECTOR METHODOLOGY DOCUMENT. Quantification of GHG Emission Reductions or GHG Removals from Sectoral GHG Mitigation Projects. Activities that avoid land use change in high mountain ecosystems, in its most recent version;

iii) Include emission reductions and removals for validated project activities only[12];

iv) Implement the activities to avoid land use changes described in the validated project document;

v) additionality, causes and agents of changes in land use, land tenure, and the baseline scenario of the new areas should be consistent with the characteristics validated for the initial areas; and,

vi) Have a start date later than the start date of the areas included in the validation.

vii) If the leakage belt overlaps with the validated expansion area, the project holder must perform the leakage belt update to include potential

[12] An activity excluded in validation cannot be included in the new areas.

displacements from land use change actions due to the implementation of project activities.

7.1.2 Reference region for baseline estimation

The project holder must delineate a reference area or region to estimate land use changes in the Project's absence. The reference region may include one or more areas. It should be similar to the project area regarding access, agents and determinants of land use change, land use categories, land use change, environmental and socioeconomic conditions, political context, and enforceable standards.

The geographic boundaries of the reference region will depend on the historical deforestation pressure of the project area and must meet the following criteria:

(a) The reference region is located in the moorland complex in which the project area is located;

(b) the reference region may include all or part of the project area;

(c) the agents and drivers of land use changes identified in the reference region can access the project area;

(d) land tenure and land use rights must be represented in the reference region, after excluding the project area;

The project holder must have adequate cartographic information to assess land use and land cover changes during the historical reference period, both in the reference region and in the project area. It should be done for at least three time periods, recording the past 10 years, prior to the start of project activities. This assessment should be carried out from the digital processing of remotely sensed images.

7.1.3 Leakage area

It is an area of forest or natural vegetation cover[13] in which activities that generate land use changes can be displaced to, beyond the project holder's control. In other words, an area to which project activities may displace the agents who generate land use changes.

The leakage area should include all areas with natural vegetation cover within the agents' mobility range identified in section 9 of this document. [14]

[13] The area of forest or natural vegetation cover must meet the eligibility criteria for the area within the project boundary.
[14] The mobility distance of the agents can be determined from secondary studies or from the collection of primary information (participatory rural appraisal).

7.2 Carbon pools and sources of GHGs

7.2.1 Carbon pools

The Intergovernmental Panel on Climate Change (IPCC) provides for the estimation of carbon stock changes in the following pools: aboveground biomass, belowground biomass, deadwood, litter, and soil organic carbon. Project holders may choose one or more carbon pools as long as they provide transparent and verifiable information and demonstrate that such a choice will not increase GHG emission reductions or removals as 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	Selected (Yes/No)	Justification/Explanation
Above-ground biomass	Yes	The change in carbon content in this pool is significant.
Below-ground biomass	Yes	The change in carbon content in this pool is significant.
Deadwood and litter	Optional	Being conservative, if the carbon content in this pool is expected to decrease, in the baseline scenario, it can be omitted.
Soil organic carbon	Yes	The change in carbon content in this pool, in high mountain ecosystems, is significant.

7.2.2 GHG sources

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

Table 2. Emission sources and GHGs selected for accounting

Source	GHG	Whether selected (Yes/No)	Justification/Explanation
Burning of woody biomass [15]	CO_2	No	CO_2 emissions due to woody biomass combustion are quantified as changes in carbon stocks.

[15] 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.

Source	GHG	Whether selected (Yes/No)	Justification/Explanation
	CH_4	Yes	CH_4 emission should be included if the presence of fires was identified in the monitoring period.
	N_2O	Yes	N_2O emission should be included if the presence of fires was identified in the monitoring period.

7.3 Temporal limits and analysis period

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

Project temporal boundaries should be defined considering the following:

(a) the project start date,

(b) the period of quantification of reductions, and

(c) monitoring periods.

7.3.1 Historical period of land use change

The analysis of historical average land use changes for the reference region shall be performed for at least two reference dates: project start date and ten years prior to the start date.

The projection of land use changes in the project area and leakage area is five years from the start date.

7.3.2 Project emission reduction

The project emissions reduction corresponds to the Project's quantification period, i.e., the period during which the holder of the initiative quantifies the GHG emissions reductions or removals, measured against the baseline, to request the issuance of Verified Carbon Credits (VCC) from the certification program.

The period of analysis for the project area during verification corresponds to the monitoring period.

8 Identification of baseline scenario and additionality

The GHG mitigation initiative holders shall identify the baseline scenario to demonstrate that the Project is additional. Under the UNFCCC, when selecting the Methodology to determine the baseline scenario of a project in the AFOLU[16] sector, the project holder shall select the most appropriate among the criteria listed below, justifying the convenience of their choice.

(a) existing or historical changes, as appropriate, in carbon stocks at project boundaries;

(b) changes in carbon stocks within the project boundary, due to land use that represents an attractive course of action considering barriers to investment;

(c) changes in carbon stocks within the project boundary, identifying the most likely land use, at the beginning of the Project.

For this Methodology's application, it is recommended to use what is stated in literal (c) above. However, the Project holder may use either of the other two approaches as long as appropriate explanation and justification for the selected option are included.

The holder of the initiative shall reliably demonstrate that all the assumptions, justifications, and documentation considered are adequate to identify the baseline scenario.

The initiative holder shall identify the baseline scenario through the following steps[17]:

PASO 0. Project start date

The date on which the activities effective GHG emission reductions begin.

Determine the project start date, describe your selection, and present evidence that proves the project starting date. Show that the start date is defined within the five (5) years prior to the project validation.

STEP 1. Identification of alternative land use scenarios

This step consists of identifying the most probable land use scenarios, which could be the baseline scenario, through the following sub-steps:

Sub-step 1a. Identification of probable land use alternatives in the project areas

Identify realistic and credible land use alternatives in the project areas in the absence of the proposed project activity. The alternatives must be feasible considering the relevant national and sectoral circumstances and policies, considering historical land uses in the Project's area of influence, economic practices, and economic tendencies in the region. These alternatives must include at least the following activities:

[16] In the Executive Board Decisions, it is noted: Afforestation and Reforestation, however, the scope of this methodology also applies to REDD+ Projects.
[17] Adapted of "Combined tool to identify the baseline scenario and demonstrate additionality" (Report EB35, Annex 19).

(a) continuation of previous land use (prior to Project);

(b) projects without the emission reduction certification;

(c) other plausible and credible land use alternatives concerning location, size, funding, experience requirements, among others. These may include alternatives that represent common practices of land use in the region where the Project is located.

Result of sub-step 1a. List of probable land use alternatives that would occur in the project area in the Project's absence.

Sub-step 1b. Consistency of land use alternatives with applicable laws and regulations

The applicable laws and regulations are given by national and sectoral policies, related to natural resources, the project activities, and the activities resultant of the land use change. Show that all land use alternatives, identified in sub-step 1a, comply with all applicable statutory and mandatory regulatory requirements.

If a land use alternative does not comply with all mandatory applicable laws and regulations, demonstrate that, based on a careful analysis of current practice (in the region where the Law is mandatory or regulation applies), the systematically applicable mandatory legal or regulatory requirements are not met.

Remove from the land use scenarios identified in sub-step 1a any land use alternatives that do not comply with applicable mandatory laws and regulations unless you can demonstrate that such alternatives result from systematic failure to comply with them.

Result of sub-step 1b. List of probable land use alternatives that comply with the legislation and mandatory norms and regulations, considering their compliance in the region or country, with respect to national or sectoral policies.

If the list resulting from sub-step 1b is empty or contains only one land use scenario, the Project is not additional.

STEP 2. Barrier analysis

Determine if the REDD+ Project faces barriers that:

(a) prevents or limits the implementation of this kind of GHG mitigation project; and,

(b) they do not prevent the implementation of at least one of the probable land use alternatives.

Apply the following sub-steps:

Sub-step 2a. Identify the barriers that would prevent the project implementation

Identify realistic and credible barriers that prevent the Project's realization if it did not contemplate participation in the carbon market. The barriers should not be specific for the project participants but should apply to the project activity. Such barriers may include, among others:

Investment barriers, *inter alia*:

- Debt funding is not available for this type of Project;
- No private capital is available due to real or perceived risks associated with national or foreign direct investment in the country where the Project is to be implemented;
- Lack of access to credit;

Institutional barriers, *inter alia*:

- Risk related to changes in government policies or laws;
- Lack of enforcement of land use-related legislation.

Barriers due to social conditions, *inter alia*:

- Demographic pressure on the land (e.g., increased demand on land due to population growth);
- Social conflict among interest groups in the region where the Project takes place;
- Widespread illegal practices (e.g., illegal grazing, illicit crops, non-timber product extraction, and tree felling);
- Lack of skilled or adequately trained labor force;
- Lack of organization of local communities.

Barriers relating to land tenure, ownership, inheritance, and property rights, *inter alia*:

- Communal land ownership with a hierarchy of rights for different stakeholders limits the incentives to undertake the project activities;
- Lack of suitable land tenure legislation and regulation to support the security of tenure;
- Absence of clearly defined and regulated property rights about natural resource products and services;
- Formal and informal tenure systems that increase the risks of landholdings' fragmentation.

The barriers identified constitute sufficient evidence to demonstrate the project additionality, only if they prevent possible initiative holders from carrying out the Project when carbon market participation is not expected.

The GHG project holder shall provide transparent and documented evidence and offer conservative interpretations of how it demonstrates the identified barriers' existence and significance. The type of evidence to be provided may include:

(a) relevant legislation, regulatory information or environmental/natural resource management norms, acts or rules;

(b) relevant studies or surveys, for example, studies made by entities like universities, research institutions, associations, companies, bilateral/multilateral institutions;

(c) relevant statistical data from national or international statistics;

(d) written documentation from the company or institution developing or implementing the Project;

(e) activities of the project holder or developer project, such as minutes from Board meetings, correspondence, feasibility studies, financial or budgetary information;

(f) documents prepared by the project developer, contractors, or project partners in the context of the proposed project activity or similar previous project implementations;

(g) written documentation of independent expert judgments from agriculture, forestry, and other land use related Government / Non-Government bodies or individual experts, educational institutions (e.g., universities, technical schools, training centers), professional associations, and others.

Sub-step 2 b. Demonstrate that the identified barriers would not prevent the implementation of at least one of the identified land use alternatives (except the project activity):

If the identified barriers also affect other identified alternatives, the project holder must demonstrate how they are less affected than they affect the Project. To be precise, it must explain how the identified barriers do not prevent the implementation of at least one of the land use alternatives. Any alternative, which prevents the barriers identified in Sub-step 2a, is not a viable alternative and should be removed from the analysis. At least one viable alternative (other than the Project) should be identified.

The baseline scenario shall be the one that is not affected by the barriers identified in sub-step 2a.

If one of Sub-steps 2a or 2b is not fulfilled, the Project cannot be considered additional through the barrier analysis.

If both Sub-steps (2a and 2b) are satisfied, proceed to Step 3 (Impact of project registration).

STEP 3. Impact of the project registration

Explain how certification and registration of the Project, and the associated benefits and incentives derived from this, would lessen the impact of the identified barriers (Step 2) and enable the Project to proceed. The benefits and incentives can be of various types, such as:

- Net anthropogenic greenhouse gas removals by sinks;
- The financial benefit proceeds from the VCC sale, including the certainty and predefined timing of the proceeds;
- Build capacity in the entities in charge of land use planning in the project area to ensure the implementation of project activities;
- Attract new stakeholders that provide the ability to implement a new technology/practice.

If Step 3 is met, the Project does not correspond to the baseline scenario and is therefore additional.

If Step 3 is not met, the Project is not additional.

9 Causes and agents that generate land use changes

The project holder shall identify, describe and analyze the causes and agents of land use change in the project area as input for:

(a) design measures and actions to mitigate land use changes; and,

(b) delimit the reference region.

This methodological complement suggests applying the conceptual guidelines for the characterization of deforestation causes and agents in Colombia proposed by IDEAM[18] and the UN-REDD Colombia Program[19]. The change from natural paramo vegetation to anthropic land uses would be homologous to the mention of deforestation.

[18] González, J. Cubillos, A., Chadid, M., Arias, M., Zúñiga, E., Cubillos, M., Joubert, F. Pérez, I. Lineamientos conceptuales y metodológicos para la caracterización de causas y agentes de la deforestación en Colombia. Instituto de Hidrología, Meteorología y Estudios Ambientales – IDEAM. Ministerio de Ambiente y Desarrollo Sostenible. Programa ONU-REDD Colombia. Bogotá, 2018.
[19] The present methodology accepts the use of the Minimum Characterization Scenario (MCS).

The key elements to develop a characterization of causes and agents of land use change are described below [20].

9.1 Spatial and temporal dimensions

The land use change has spatial and temporary dimensions that must be characterized. The spatial dimension is necessary to know and analyze the phenomenon's location and extent (project area and proposed reference region). Understanding its temporal dimension allows understanding deforestation and forest degradation in terms of its historical antecedents, current dynamics, and probable future behavior (historical period of land use change).

9.2 Context

An adequate characterization of the causes and agents of land use change in a particular area implies recognizing and understanding the socio-environmental surrounding of the phenomenon and analyzing its influence on land use change dynamics.

a) The *territorial context* refers to the biophysical environment and how societies relate and construct their living space. It includes occupation, land use, social interaction, and legal and regulatory aspects that govern these dynamics.

b) The *sociocultural context* is based on the relationships between societies and how different human groups interact and organize themselves to live and establish production in a community.

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

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

[20] The following documents can serve as a basis for the identification of the agents and drivers of land use change in high mountain ecosystems: Instituto de Hidrología, Meteorología y Estudios Ambientales, Instituto de Investigación de Recursos Biológicos Alexander von Humboldt y Consorcio para el Desarrollo de la Ecorregión Andina. (2018). Propuesta de Estrategia para monitoreo integrado de los ecosistemas de alta montaña de Colombia. Bogotá: IDEAM-IAvH-Codesan, 54 pp. Ungar, P. (ed.) (2015). Hojas de ruta. Guías para el estudio socioecológico de la alta montaña en Colombia. Bogotá: Instituto de Investigación de Recursos Biológicos Alexander von Humboldt.
Paramos habitados: desafíos para la gobernanza ambiental de la alta montaña en Colombia.

9.3 Key actors, interests, and motivations

The land use process involves multiple official actors, non-governmental organizations and civil society, among others. Within this group are the agents of land use change and those actors that indirectly promote forest transformation processes. It is essential to characterize the interests or motivations that determine their decisions and the relationships they establish with other key actors. In this sense, it is necessary to include the underlying causes of land use change identified for the project area, pointing out their importance within the group of factors that motivate agents to modify the natural coverage.

Each key actor involved in land use change dynamics has a degree of responsibility and influence and a geographic expression that must be characterized and related to the phenomenon of change of natural cover to anthropic use and cover.

9.4 Economic activities and their importance

Activities that directly cause land use change should be characterized in terms of the spatial patterns associated with their presence and their economic and sociocultural importance for the agents and other key stakeholders involved. Activities with a high level of sociocultural roots require different measures and actions than those where economic benefit prevails over other interests.

9.5 Direct and indirect impact

Each cause and agent has a differential impact on natural vegetation. The impact can be assessed qualitatively or quantitatively. Quantitative impact estimates can be made employing a spatial analysis that determines the relationship between the identified cause and the calculated land use change. Qualitative estimates are made through the use of stakeholder participation techniques in the territory.

9.6 Relations and synergies

The project holder shall identify and analyze the interactions and synergies between all the elements to define the activities that decrease land use change.

9.7 Land use change chain of events

The analysis of chains of events seeks to identify the relationships between main groups of agents and causes to try to explain the sequence of events that usually leads to the loss of natural cover in a particular area.

For each activity that causes a natural cover loss, a causal chain of at least 3 links shall be identified, which is composed of a differential sequence of events or conditions, resulting in the occupation of the territory, as follows:

a) Identify each of the activities that generate a loss of natural cover. If possible, these should be grouped according to the most common direct causes of change;

b) Identify the agents associated with the actions and direct causes of change established;

c) Identify the underlying causes that promote or facilitate the agents' decisions to carry out the actions, resulting in a natural cover loss.

10 Project activities

Activities to avoid land use changes in the project area must be designed based on the analysis of causes and agents. Likewise, the communities (if applicable) must be considered, based on participatory construction, in the case of peasant territories. The design of each project activity must include at least the following:

(a) activity ID;

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

(c) consultation mechanism for the definition of project activities and aspects of participatory construction;

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

(e) implementation schedule;

(f) indicators to report the activity's progress: name, type, goal, unit of measurement, and responsible for measurement.

11 Safeguards

Implementing activities that avoid land use change can generate benefits to communities and the environment and reduce GHG emissions. However, there may be some social and environmental risks associated with their implementation. In this sense, the implementation of REDD+ safeguards identified by Colombia is recommended, which are measures aimed at preventing the affectation of fundamental social, economic, or environmental rights and the occurrence of adverse impacts due to the design and implementation of project activities. It also includes measures to improve the obtaining and distribution of benefits generated by project activities.

In the national interpretation of the safeguards for REDD+, fifteen (15) elements have been defined in Colombia. They are numbered with a letter that refers to the Cancun safeguard to which it corresponds and a number that identifies it. The national interpretation's safeguard elements can be organized into three themes: institutional, social, cultural, environmental, and territorial.

The initiative holder shall demonstrate compliance with all the safeguards presented in Table 3, including the definition of monitoring, reporting, and verification indicators. [21]

Table 3. Safeguards REDD+

Thematic	Safeguard Cancun	National safeguard	Description
Institutional	A. Consistent with national and international forestry programs and agreements	1.Correspondence with national legislation	The Project is developed within the framework of the National Forestry Development Plan, international conventions, and agreements signed by Colombia in the areas of Forests, Biodiversity, and Climate Change, as well as the national policies corresponding to these agreements. All proposed REDD+ Policies, actions, and measures must be in correspondence with: • international agreements signed by Colombia. • national legislation (the Constitution, laws, and decrees). • national policies, programs, and projects.
	B. Transparency and effectiveness of forest governance structures	2.Transformation and access to the information	Stakeholders have transparent, accessible, and pertinent information related to REDD+ actions in the information platforms or media determined. If there are ethnic groups involved and they do not speak Spanish well, it shall be ensured that there are interpreters for their language in the consultation and information areas for their language, as well as understanding. Be clear in reporting on: • which entity is in charge of formulating and implementing the measure;

[21] Camacho A., Lara I., Guerrero R. D. 2017. "Interpretación Nacional de las Salvaguardas Sociales y Ambientales para REDD+ en Colombia" MADS, WWF Colombia, ONU REDD Colombia. Bogotá-Colombia.

Thematic	Safeguard Cancun	National safeguard	Description
			• what are the benefits to be delivered to the communities in the territory • the commitments made by the parties involved in the implementation of the measures
		3. Accountability	The institutions and actors present reports on their administration on REDD+ activities to the partners involved, institutions, and the general public, including information on applying and compliance with safeguards. Those in charge of implementing REDD+ activities must convene accountability spaces where management reports are presented: what has been done, how it has been done, how much has been spent and how the resources have been invested, what the results are. Should be included the information on the status of implementation of safeguards for risk mitigation and benefit enhancement. Stakeholders are committed to attending these informative forums. Accountability reports must be public and accessible to diverse stakeholders.
		4.Recognition of forest governance structures	REDD+ actions are developing under the existing forest governance structures established by the regulations and by establishing the necessary structures among the actors involved in the process (strengthening or creating new structures can be a mechanism for implementing governance). In some cases where various stakeholders are involved, it may be necessary to establish new arrangements or articulation mechanisms for decision making. These may include forestry roundtables, follow-up committees, or the creation of spaces for dialogue with the community action boards.

Thematic	Safeguard Cancun	National safeguard	Description
		5.Capacity building	The strengthening of the technical, legal, and administrative governance capacities of the actors directly involved is guaranteed so that the parties can make documented, analyzed, and informed decisions. It is necessary to account with programs that contribute to the capacity building of the actors involved as required in each case: • technical capacities such as REDD+ training, climate change, forest governance, sustainable forest management, conservation, monitoring, and sustainable production models. • legal skills: training in national legislation and international agreements related to these issues. • administrative skills: training in tools for project follow-up, resource management, and accountability.
Social and cultural	C. Respect for the traditional knowledge and rights of the communities	6.Free, prior and informed consent	When a measure or action affects or may directly affect one or more ethnic groups, the national provisions on consultation and free, prior, and informed consent established in legislation and jurisprudence must be applied, as well as the guidelines issued by the Ministry of the Interior as the competent entity in this area, with the support of the control agencies.
		7.Respect traditional knowledge	The traditional knowledge systems and visions of ethnic and local peoples and communities are recognized, respected, and promoted, as established in national legislation and compliance with international agreements. To develop an initiative to reduce deforestation, the different cultures that inhabit the territories must be considered, respecting their forms of understanding and relating to the environment. Communities'

Thematic	Safeguard Cancun	National safeguard	Description
			traditions, uses, and customs are not affected.
		8.Benefit-sharing	The participation and fair and equitable sharing of benefits generated by policies, measures, and actions to reduce deforestation for ethnic and local peoples and communities, and of all those benefits derived from traditional knowledge, innovations, and practices for the conservation and sustainable use of forests, their diversity and Ecosystem Services are guaranteed.
		9.Territorial rights	The collective and individual territorial rights of ethnic and local peoples and communities are respected; also, their cultural, economic, and spiritual use and significance. For this purpose, the land tenure arrangements in the areas where REDD+ measures and actions are expected to be implemented must be known, and decisions must be made accordingly.
	D. Full and effective participation	10.Participation	All stakeholders' right to participate fully and effectively is respected to ensure governance and adequate decision-making on REDD+. Each stakeholder group's participation structures, especially communities, must be recognized and respected following national legislation and international agreements signed by Colombia.
Environmental and territorial	E. Conservation and benefits	11.Forest conservation and its biodiversity	REDD+ projects support forest conservation and the implementation of measures established for this purpose. REDD+ projects developed in the country shall not be detrimental to forests' conservation and the biodiversity they harbor.
		12.Provision of environmental goods and services	REDD+ projects support the provision and enjoyment of ecosystem services.

Thematic	Safeguard Cancun	National safeguard	Description
			The implementation of REDD+ projects shall not directly or indirectly affect ecosystems' benefits.
	F. Prevent reversion risks	13. Environmental and territorial planning	REDD+ initiatives support the consolidation of land use and environmental management instruments in the legislation, focusing on conservation and sustainable forest management. REDD+ initiatives carried out in the country recognize, respect, adapt or strengthen the measures and instruments of territorial and environmental planning defined by national legislation. It is recommended to encourage citizen participation in these instruments' formulation and adjustment according to land use. The specific forms of land use planning of ethnic groups and local communities shall also be recognized to support their permanence over time.
		14.Sectoral planning	Sectoral REDD+ actions are proposed based on environmental and territorial planning instruments, as well as legislation related to the conservation of forests and their biodiversity. When a sector defines and implements REDD+ actions, these must be articulated with national legislation that protects forests, their conservation, and the diversity that they harbor.
	G. Avoid emission displacement	15.Forestry control and surveillance to prevent emissions displacement.	REDD+ initiatives incorporate measures to reduce emissions displacement in their design and ensure opportune monitoring and control when emissions displacement occurs. Community monitoring, articulated with early warning systems for deforestation, and the activation of protocols that allow for timely responses, can be decisive in ensuring that the problems associated with forest loss

Thematic	Safeguard Cancun	National safeguard	Description
			and forest degradation do not spread to other places.

Source: Camacho et al. (2017)[22]

12 GHG emission reduction from project activities

12.1 Stratification

If the project areas' biomass distribution is not homogeneous, doing a stratification process improves the Project's biomass estimates' accuracy.

The project holder should define different strata for the baseline scenario and the with-project scenario. These definitions optimize the accuracy in estimating GHG emission reductions or removals.

The present Methodology allows the use of only one stratum (see Section 12.3). Inclusion of other strata requires estimation of carbon contents from vegetation inventory data for the project area. [23]

12.2 Activity data

Changes in the area under natural vegetation cover (SCNC) data are the activity data for estimating land use change. The SCNC estimation depends on the reference region identified under the provisions of section 7.1.2 (Activity data).

12.2.1 Estimation of the land use change

The project holder shall analyze changes from natural vegetation cover to another cover [24] between at least two dates (start date and ten years prior to the start date).

22 Camacho A., Lara I., Guerrero R. D. 2017. "Interpretación Nacional de las Salvaguardas Sociales y Ambientales para REDD+ en Colombia" MADS, WWF Colombia, ONU REDD Colombia. Bogotá-Colombia.

23 The holder of the initiative must present the methodological approach for carbon estimation in the different strata and include the evaluation of uncertainty. See Torres, A. M., Peña, E. J., Zúñiga, O., & Peña, J. A. (2012) for more information on the quantification of above-ground and below-ground biomass in paramos and GOFC-GOLD REDD Sourcebook to ensure good practice in carbon estimations.

24 The holder of the initiative must present the methodology used in the delimitation of natural cover and changes to other land uses. It is suggested that the following documents be used as a basis:
IDEAM, J. Rodríguez, V. Peña, Análisis de Dinámicas de Cambio de las Coberturas de la Tierra en Colombia, Escala 1:100.000 Periodos 2000-2002 y 2005-2009. 148 pag.
Lineamientos metodológicos para monitoreo de coberturas de la tierra.

To calculate the area with loss of natural vegetation cover between the two dates, only the areas for which natural vegetation cover is detected on the first date and anthropic land use on the second date[25] shall be accounted so that there is the certainty that the event occurred in the period analyzed (land use change).

Natural cover losses detected after one or several dates without information[26] should not be included in the calculation to avoid overestimated rates in periods when areas without information increase due to different factors, for example, in climatic periods of high cloudiness or failures in the satellite programs' sensors that take the images.

12.2.2 Annual historical change in the reference region

This equation estimates the estimation of annual historical land use change in the without project scenario [27]:

$$SCNC_{yr} = \left(\frac{1}{t_2 - t_1} \ln \frac{A_2}{A_1}\right) x\, A_p$$

Where:

$SCNC_{yr} =$	Change in the area under natural vegetation cover in the without project scenario; ha yr^{-1}
$t_2 =$	Final year of the reference period, year
$t_1 =$	Initial year of the reference period, year
$A_1 =$	Area in natural vegetation cover of the reference area, t1; ha
$A_2 =$	Area in natural vegetation cover of the reference area, t2; ha
$A_p =$	Eligible area; ha

The SCNC is the historical average change of the project area and is the value used to represent the expected loss of natural vegetation cover in the without-project scenario.

12.2.3 Projection of annual changes in land use in the scenario with Project

The estimation of the annual changes, in the scenario with Project, is carried out with the equation:

$$SCNC_p = SCNC_{lb}\, x\, (1 - \%PD)$$

Instituto de Hidrología, Meteorología y Estudios Ambientales, Instituto de Investigación de Recursos Biológicos Alexander von Humboldt y Consorcio para el Desarrollo de la Ecorregión Andina. (2018). Propuesta de Estrategia para monitoreo integrado de los ecosistemas de alta montaña de Colombia. Bogotá: IDEAM-IAvH-Codesan, 54 pp.

[25] Example: removal of frailejon-dominated cover for the establishment of a crop.

[26] Complementary information may be used to reduce the area without information. Detailed information about the methodology, the relevance of the use of the selected information source and the evaluation of the accuracy of the image classification should be presented.

27 Puyravaud, Jean-Philippe. "Standardizing the calculation of the annual rate of deforestation." Forest ecology and management 177.1-3 (2003): 593-596.

Where:

$SCNC_{p^{28}}$ =	Change in the area with natural vegetation cover in the scenario with Project; ha yr-1
$SCNC_{lb}$ =	Change in the area under natural vegetation cover in the without project scenario; ha yr-1
%PD =	Projection of the decrease in land use changes due to implementing project activities.

12.2.4 Historical annual land use changes in the leakage area

The annual historical deforestation in the leakage area is estimated whit the equation:

$$SCNC_{lk,yr} = \left(\frac{1}{t_2 - t_1}\right) x \,(A_{1lk} - A_{2lk})$$

Where:

$SCNC_{lk,yr}$ =	Annual change in the surface of natural vegetation cover in the leakage area; ha
t_2 =	Final year of the reference period; year
t_1 =	Initial year of the reference period; year
$A_{1,lk}$ =	Natural vegetation-covered surface in the leakage area, at the start date; ha
A_{2lk} =	Natural vegetation-covered surface in the leakage area, at the final date; ha

12.2.5 Projected annual land use change in the leakage area in the project scenario

The projected annual land use change in the leakage area in the project scenario is estimated with the equation:

$$SCNC_{project,lk,yr} = CSNC_{lk,bl} \; x \; (1 + \%E_{lk})$$

Where:

$SCNC_{project,lk,yr}$ =	Annual change in the surface covered by natural covert in leakage area in the project scenario; ha
$SCNC_{lk,bl}$ =	Annual change in the surface covered by natural cover in leakage area in the baseline scenario; ha
$\%E_{lk}$ =	Percentage of emissions increase in the leakage area due to the implementation of project activities. The use of a default value of 10% is allowed in this Methodology.

12.3 Emissions factors

The Methodology presents the values of aboveground biomass, belowground biomass, and soil carbon pools. If the project holder intends to use additional pools, it shall present a detailed description of their estimation, according to IPCC guidelines, and demonstrate that their use does not generate an overestimation of emissions in the baseline.

Emission factors are presented following the guidelines and assumptions used in the national NREF:

- Belowground biomass is included differentially to soil organic carbon content[29].
- It is assumed that all carbon in the above-ground and below-ground biomass pool is emitted in the same year as the deforestation event.
- A gross emission is assumed in which the soil carbon content (SOC) at 30 cm[30] is emitted in equal proportions for 20 years after the land use change event occurs.

12.3.1 Emission factor of total biomass

Total biomass is estimated from aboveground biomass (AB) and belowground biomass (BB). The carbon content of total biomass (CFTB) is the product of the TB (dry) and the carbon fraction of dry matter (CF). Total biomass carbon dioxide equivalent (CFBeq) is the product of CBF and the molecular ratio constant between carbon (C) and carbon dioxide (CO_2). The estimate of CFBeq is calculated according to the equation:

$$CFBeq = BT\ x\ CF\ x\ \frac{44}{12}$$

Where:

$CFBeq =$ Carbon dioxide equivalent, content in the total biomass; $tCO_2e\ ha^{-1}$

$TB =$ Total biomass; $t\ ha^{-1}$
The Methodology accepts using a single stratum for paramo vegetation with a total biomass value of 26 tC ha-1[31]. The initiative holder may use a different value by providing transparent and verifiable information (see section **¡Error! No se encuentra el origen de la referencia.**).

$CF =$ Carbon fraction of the dry matter (0,47)

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[29] The belowground biomass emission factor cited in this methodology corresponds to roots greater than 5 mm in diameter. The SOC emission factor presented in the methodology comes from IGAC data and it is assumed that the quantification of %CO includes a screening of soil samples. (<2 mm).

[30] The holder of the initiative may include the estimation of COS at a depth greater than 30 cm using the guidelines presented in Annex B. In this case, the COS estimation shall be performed in areas with and without natural cover and the difference in COS between both covers shall be used in the equation presented in section 12.3.2.

[31] Torres, A. M., Peña, E. J., Zúñiga, O., & Peña, J. A. (2012). Evaluación del impacto de actividades antrópicas en el almacenamiento de carbono en biomasa vegetal en ecosistemas de alta montaña de Colombia. Boletín Científico Museo de Historia Natural, 16(1), 132-142.

$\frac{44}{12} =$ The molecular ratio constant between carbon (C) and carbon dioxide (CO_2)

12.3.2 Emission factor of soil carbon

Annual emission rates for soil organic carbon can be determined using the following options: (a) using default values, (b) project's estimates[32]. These are described below.

(a) Using default values

To estimating emissions from soils, a gross emission is assumed where the soil organic carbon (SOC) is emitted in equal proportions for 20 years once the land use change event occurs. According to the following equation, the annual rate of carbon emissions in 20 years (SOC20years) was calculated by dividing the SOC of each natural region by 20.

$$SOCeq = \frac{SOC}{20}\ x\ \frac{44}{12}$$

Where:

$SOCeq =$ Carbon dioxide equivalent content in soils; $tCO_2e\ ha^{-1}$
$SOC =$ Carbon content of soils; $tC\ ha^{-1}$
$\frac{44}{12} =$ The molecular ratio constant between carbon (C) and carbon dioxide (CO_2)

Thus, based on IGAC (2020)[33] information, Table 4 presents soil organic carbon values for ten paramo complexes in Colombia.

[32] The IGAC has the description of the cartographic units of soils, under the terms of the guide G40100-02.
[33] Data taken from: Gutiérrez Díaz, J. S., Ordoñez Delgado, N., Bolívar Gamboa, A., Bunning, S., Guevara, M., Medina, E., … Vargas, R. (2020). Estimation of organic carbon in paramo ecosystem soils in Colombia. Ecosistemas, 29(1), 1–10. https://doi.org/10.7818/ECOS.1855. If the project area is outside the ten districts, the holder of the initiative must estimate the carbon content from the soil profiles available in the Soil Information System of Latin America and the Caribbean (Sistema de Información de Suelos de Latinoamérica y el Caribe) (URL: http://54.229.242.119/sislac/es).

Table 4. Soil organic carbon (SOC) for the ten paramo districts in Colombia.

District	SOC (tC ha⁻¹)	SOC20years (tC ha⁻¹)	SOCeq (tCO2e ha⁻¹)
Perijá	147,48	7,37	27,04
Altiplano	181,91	9,10	33,35
Boyacá	161,40	8,07	29,59
Cundinamarca	176,21	8,81	32,31
Frontino-Tatamá	175,58	8,78	32,19
Sonsón	158,42	7,92	29,04
Viejo Caldas-Tolima	152,96	7,65	28,04
Santander	158,65	7,93	29,09
Macizo	169,18	8,46	31,02
Nariño-Putumayo	167,14	8,36	30,64

(b) project's estimates

The estimation of emissions related to soil organic carbon (SOC) changes shall be done separately for each soil mapping unit[34] identified within the project boundaries. The guidelines for estimating SOC from project data are described in Annex A.

12.4 GHG emission in the analysis period

The annual emission by land use change in the without-project scenario is calculated according to the equation:

$$AE_{bl} = SCNC_{bl}\ x\ (CFB_{eq} + SOC_{eq})$$

Where:

AE_{bl} = Annual emission in the without project scenario; $tCO_2\ ha^{-1}\ yr^{-1}$
$SCNC_{bl}$ = Historical changes in the without project scenario; $ha\ yr^{-1}$
CFB_{eq} = Carbon dioxide equivalent in total biomass; $tCO_2e\ ha^{-1}$
SOC_{eq} = Carbon dioxide equivalent in the soil; $tC\ ha^{-1}$

The annual emission by land use change in the project scenario is estimated following the equation:

$$AE_{project} = SCNC_{project}\ x\ (CBF_{eq} + SOC_{eq})$$

Where:

$AE_{project}$ = Annual emission in the project scenario; $tCO_2\ ha^{-1}$

[34] The IGAC has the description of the cartographic units of soils, under the terms of the guide G40100-02.

$SCNC_{project} =$ Land use change in the project scenario; ha yr^{-1}
$CBF_{eq} =$ Carbon dioxide equivalent in total biomass; tCO2e ha^{-1}
$SOC_{eq} =$ Carbon dioxide equivalent in soil; tCO2e ha^{-1}

The annual emission from land use change in the leakage area is estimated using the following equation:

$$AE_{lk,yr} = SCNC_{lk}\ x\ (CBF_{eq} + SOC_{eq})$$

Where:

$AE_{lk,yr} =$ Annual emission in the leakage area; tCO2 ha^{-1} yr^{-1}
$SCNC_{lk} =$ Land use change in the leakage area; ha yr^{-1}
$CBF_{eq} =$ Carbon dioxide equivalent in total biomass; tCO2e ha^{-1}
$SOC_{eq} =$ Carbon dioxide equivalent in soil; tCO2e ha^{-1}

12.5 Expected GHG emissions reduction due to project activities

Emission reductions from avoided land use changes in high mountain ecosystems in the project scenario are estimated according to the following equation:

$$ER_{project} = (t_2 - t_1)\ x\ (AE_{bl} - AE_{project} - AE_{lk})$$

Where:

$ER_{project} =$ Emission reductions from avoided land use changes in the project scenario; tCO_2e
$t_2 =$ Final year of the reference period; year
$t_1 =$ Initial year of the reference period; year
$AE_{bl} =$ Emission from land use changes in the baseline scenario; tCO_2e yr^{-1}
$AE_{project} =$ Emission from land use changes in the project area; tCO_2e yr^{-1}
$AE_{lk} =$ Emission from land use changes in the leakage area; tCO_2e yr^{-1}

13 Uncertainty management

According to GOFC-GOLD (2016)[35], uncertainty is *a property of a parameter estimate and reflects the degree of knowledge lack 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*

[35] 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). Disponible en: http://www.gofcgold.wur.nl/redd/sourcebook/GOFC-GOLD_Sourcebook.pdf.

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%.[36][37]

Under the PROCLIMA Program, uncertainty management is determined by the accuracy of the maps used to estimate activity data values and the application of discounts1[38] in emission factors. For activity data, accuracy should be greater than 90%. The accuracy assessment should be made from the use of field observations or analysis of high-resolution imagery. For emission factors, an uncertainty of 10% is acceptable for the use of average carbon values (assessment should be done per repository). If the uncertainty is greater than 10%, the 95% confidence interval's lower value should be applied[39].

14 Monitoring plan

The project holders shall describe the procedures established to follow-up on the project activities, the safeguards compliance, and the GHG emission reduction or removals in the Project.

The monitoring plan should provide the collection of all relevant data necessary to:

(a) Verify that the applicability conditions listed in numeral 4 of this document have been met;

(b) Verify changes in carbon stocks in selected pools;

(c) Verify project emissions and leakage;

The data collected shall be archived for at least two years after the end of the last project period, including the data and parameters monitored, the methods used to generate data and their proper collection and archiving, as well as the processes related to sampling models and data quality control.

14.1.1 Monitoring of the project boundary

The Project's geographic limits, constituted by the eligible areas[40] over which project activities are developed, shall be included in a Geographic Information System (GIS), georeferencing the total project areas, including the reference region and the leakage area.

[36] The project holder should describe how it addressed the GOFC-GOLD (2016) guidelines in estimating uncertainty.
[37] It is not necessary to estimate the uncertainty associated with the values defined in the NREF.
[38] The discounts are different from and in addition to the 15% reserve provided for in section 11.8 of the PROCLIMA Program
[39] The project holder may use data from scientific studies that have a data uncertainty of less than 20%.
[40] Eligible areas refers to areas that meet the condition of presence of natural cover, on the reference dates established by the PROCLIMA Program.

Thus, the monitoring of the emission reduction from land use changes shall be carried out for the project boundary's geographic areas. Periodic verification of land use change in the Project shall be done using the Methodology in section 12.2.

14.1.2 Monitoring of the project activities implementation

The project holder shall design a monitoring plan for each proposed activity, according to the following table's information.

Table 5. Monitoring of the project activities implementation

Activity ID	
Indicator ID	
Indicator name	
Type[41]	
Goal[42]	
Measurement unit	
Monitoring methodology	
Monitoring frequency	
Responsible for measurement	
Result indicator in the reporting period	
Documents to support the information	
Observations	

14.1.3 Monitoring of the permanence project

The project holder must identify the Project's non-permanence risks and design a monitoring plan that includes mitigation measures, monitoring indicators, and reporting procedures[43]. Biophysical and socioeconomic risks should be assessed, including fires, floods, land tenure disputes, conflicts between project stakeholders, non-ownership of project activities, and governance deficits.

14.1.4 Monitoring of the project emissions

In the project scenario, at a minimum, activity data should be monitored. Validated emission factors can be applied in the estimation of monitored emissions. The parameters for the estimation of activity data are determined following the guidelines of section 12.2.

[41] Result, product or impact.
[42] Expected value and time for compliance.
[43] In case of fires, the affected area must be identified, the N_2O and CH_4 emissions must be estimated and included in the quantification of project emissions during the monitoring period.

Activity data

Land use changes (by year) in the project area

The following equation allows estimating land use changes in the project area during the monitoring period:

$$SCNC_{project,yr} = \left(\frac{1}{t_2 - t_1}\right) x\ (A_1 - A_2)$$

Where:

$SCNC_{project,yr}$ = Annual change in the surface with natural vegetation cover in the project area; ha
t_2 = Final year of the reference period; year
t_1 = Initial year of the reference period; year
A_1 = Natural vegetation cover the surface in the project area at the beginning of the monitoring period; ha
A_2 = Natural vegetation cover the surface in the project area at the end of the monitoring period; ha

Annual changes in the land use in leakage area

The estimation of the annual land use in the leakage area in the monitoring period is estimated by equation:

$$CSCN_{lk,yr} = \left(\frac{1}{t_2 - t_1}\right) x\ (A_{lk,1} - A_{lk,2})$$

Where:

$CSCN_{lk,yr}$ = Annual change in the surface covered by forest and natural vegetation Cover in the leakage area; ha
t_2 = Final year of the reference period; year
t_1 = Initial year of the reference period; year
$A_{lk,1}$ = Natural vegetation cover the surface in the leakage area at the beginning of the monitoring period; ha
$A_{lk,2}$ = Natural vegetation Cover surface in the leakage area at the end of the monitoring period; ha

GHG emissions in the analysis period

The following equation estimates the annual emission from land use change in the project area:

$$E_{project,yr} = SCNC_{project}\ x\ (CBF_{eq}\ +\ COS_{eq})$$

Where:

$E_{project,yr}$ = Annual emissions in the project area; tCO2 ha^{-1}
$SCNC_{project}$ = Land use change in the project area; ha año^{-1}
CBF_{eq} = Carbon dioxide equivalent in the total biomass; tCO2e ha^{-1}
COS_{eq} = Soil organic carbon; tC ha^{-1}

The equation estimates the annual emission in the leakage area:

$$E_{lk,yr}\ = [SCNC_{project,lk}\ x\ (CBF_{eq}\ +\ COS_{eq})]\ -\ AE_{lk,bl}$$

Where:

$E_{lk,yr}$ = Annual emissions in the leakage area; tCO2 ha^{-1}
$SCNC_{project,lk}$ = Changes in the land use in the leakage area; ha año^{-1}
CBF_{eq} = Carbon dioxide equivalent in the total biomass; tCO2e ha^{-1}
$AE_{lk,bl}$ = Annual emissions in the leakage area in the baseline scenario; tCO_2e

Reduction emissions due to the project activities

Emission reductions from avoided land use changes in high mountain ecosystems during the monitoring period are estimated according to the following equation:

$$ER_{project,mp} = (t_2 -\ t_1)\ x\ (AE_{bl} -\ AE_{project,mp} - AE_{lk})$$

Where:

$ER_{project,mp}$ = Emission reduction from avoided changes land use in the monitoring period; $tCO_2e\ yr^{-1}$
t_2 = Final year of the monitoring period
t_1 = Initial year of the monitoring period
AE_{bl} = Emission by land use changes in the baseline scenario; tCO_2e
$AE_{project,mp}$ = Emission by land use changes in the project area in the monitoring period; tCO_2e
AE_{lk} = Emission by land use changes in the leakage area in the monitoring period; tCO_2e

14.2 Quality control and quality assurance procedures

The 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[44]. 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.

14.2.1 Review of the information processing

The processing of the data collected in the field and the digital systems recording shall be reviewed. The recorded data shall 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.

14.2.2 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) [45], and measurement and monitoring reports.

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

[44] IPCC GPG LULUCF (2005). http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf/spanish/full.pdf

[45] Geographic information must be handled following the quality standards of the Colombian Technical Norm NTC 5043. In addition, the holder of the GHG mitigation project must have the respective metadata, following the guidelines of the Geographic Storage Model (ANLA). Consult at: http://portal.anla.gov.co/sistema-informacion-geografic

ANNEX A. Emission Factor of Soil Organic Carbon (SOC)[46]

Sampling

Each sampling point requires a box or *calicata* of 50 cm x 50 cm x 60 cm. For each, the sampler takes six (6) simples, three (3) for bulk density calculation, and three (3) for organic carbon calculation, at deeps of 0 – 15 cm, 15 – 30 cm, and 30 – 50 cm (Figure 1).

Bulk density sampling starts on the most superficial range (0 – 15 cm), while organic soil's starts in the deepest one (30 – 50 cm). The sampler shall take both samples in the medium point of each range, from the "wall" that gets more natural light.

In sloping areas, samples come from the "wall" against the soil inclination (Figure 2).

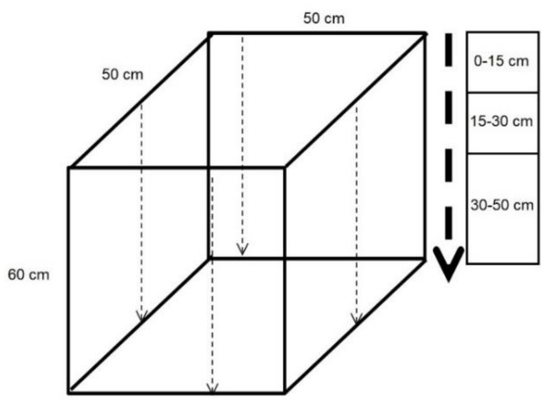

Figure 1. Calicata or box's sampling deeps

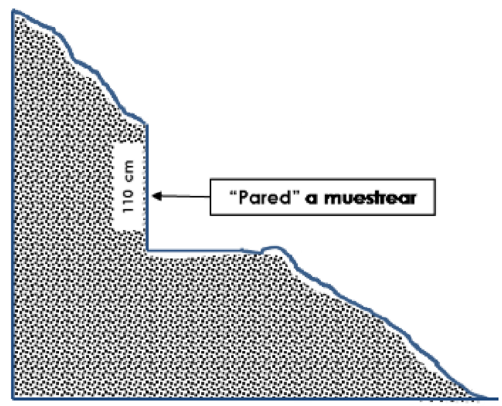

Figure 2. Sampling wall location in sloping areas

Once open, demarcate the sampling area with a pedological knife and measuring tape in the required sampling points deeps and vertically divide the box into equal parts. In the first, sample bulk density, in the second, sample organic carbon content.

<u>Bulk density</u>

First samples should be bulk density to avoid vastly disturbing soils. Such samples are taken with an Uhland auger. The sampler should ensure samples reliability, as follows:

1. Use plastic bags with filled labels for identifying each sample.
2. Register in the label the sampling cylinder dimensions, both height and wide.
3. Clean the box surface with a little stick.

[46] Metodología de muestreo basada en: Arias Monsalve, A. F., Agustín Chávez, A., Fernández, C. J., Querubín Gonzales, D. J., Arias Burgos, I., Gutiérrez, J. S., ... Camacho Hilarión, C. A. (2018). Identificación de la hoja de ruta y procedimientos para la estimación del contenido de carbono orgánico en suelos de paramos y humedales. Repositorio Institucional de Documentación Científica Humboldt, 7–17.

4. Put two cylinders on the lower side of the Uhland auger.
5. Put the Uhland auger vertical to the ground, verifying its lower side touches the soil.
6. Softly hit the upper side of the Uhland auger with a rubber mallet and sink it until half of each sampling range size, around 7,5 cm for the first, 22,5 cm for the second, and 40 cm for the third.
7. Sink the second cylinder entirely in the soil.
8. Slowly remove the Uhland auger, so the soil sample is kept unchanged.
9. Carefully clean the cylinders for the next samples.
10. Repeat this process from step four (4) for the remaining samples.

Classify soil by rock fragments type

Classify soil following box's rocks fragment size types: gravel, coarse gravel (*cascajo*), pebbles, slab, stones, and cobbles (*pedregón*).

Table A.1. Soil rock fragments type

Code	Type	Irregular forms (diameter, cm)	Flat shapes (longitude, cm)
G	Gravel	0.2 - 2	
C	Coarse gravel	2 - 8	
J	Pebble	8 - 25	
L	Slab		0.2 - 38
P	Stones	25 - 60	38 - 60
R	Cobble	>60	> 60

The next steps establish soil fragments types in soils:

1. where fragments were found, make a perpendicular square.
2. Divide the previous square into four equal parts (Figure 3).
3. Calculate rock fragments percentage in each square using the graphic guideline for quantifying field rock fragments[47].
4. For each square, calculate and register average results.

[47] Gee, G., Bauder, J. 1986. Particle-size Analysis, En: Klute, A. (Ed.), Methods of Soil Analysis, Part 1. Physical and Mineralogical Methods, pp. 383– 411. SSSA Book Series. Soil Science Society of America, American Society of Agronomy. Madison, United States.

Figure 3. Rock fragments types in soils

<u>Organic carbon (%C)</u>

Second samples for %C estimation are taken from the half left. The sampler should demonstrate samples reliability, as follows:

1. Use plastic bags with filled labels for identifying each sample.
2. Clean the little stick and the pedologic knife.
3. Sink the little stick in the middle of the deeper soil sampling range, around 7,5 cm for the first, 22,5 cm for the second, and 40 cm for the third.
4. Put two cylinders on the lower side of the Uhland auger.
5. Put the Uhland auger vertical to the ground, verifying its lower side touches7,5 cm for the first, the soil.
6. Softly hit the upper side of the Uhland auger with a rubber mallet and sink it until half of each sampling range size, around 40 cm for the third, 22,5 cm for the second, and 7,5 cm for the first. Starting by the most profound range to avoid sampling pollution.
7. Taking a soil sample of around 500 gr, and put it in a labeled bag, send it to the selected laboratory.
8. If saturated or organic soils, take at least 1000 gr.
9. Repeat this process from step two (2) for the remaining samples.

Note 1: Verify samples number and register samples' deeps, cylinder dimensions. Each sample shall be packed in a double bag with its label.

Note 2: When limiting deep exists, sample until the maximum allowed profound and register limiting factor and its deep.

Soil Organic Carbon calculation (SOC)

Soil Organic Carbon calculation depends on four (4) variables: organic carbon percentage (%), bulk density (gr cm^{-3}), size particles distribution, and soil deep.

1. %C is evaluated through humid combustion of the Walkley-Black method.[48]
2. Bulk density is evaluated with the known volume cylinder method.[49]
3. Soil Organic Carbon calculation is evaluated with:

$$SOC = [OC] * DA * T * \left(1 - \frac{RF}{100}\right)$$

Where:

$SOC =$ Soil organic soil; t C ha^{-1}
$OC =$ Organic carbon concentration in the soil
$BD =$ Bulk density; gr cm^{-3}
RF = Percentage occupied by rock fragments in the profile's first 30 cm
T = Analyzed layer thickness (30 cm)

[48] Walkley, A., Black, I. 1934. An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Science 37, 29–37.
[49] Blake, G., Hartge, K. 1986. Bulk Density, En: Klute, A. (Ed.), Methods of Soil Analysis, Part 1. Physical and Mineralogical Methods, pp. 363–375. SSSA Book Series. Soil Science Society of America, American Society of Agronomy. Madison, United States.

Document history

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