METHODOLOGICAL DOCUMENT
AFOLU SECTOR

BCR0007 Conservation and restoration of natural continental wetlands

BIOCARBON CERT®

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This methodological document was developed by the technical team of "*Proyecto CO2 Humedales*" of Fundación Natura, within the framework of agreement No. 3044288 signed between Ecopetrol and Fundación Natura.

The "*Proyecto CO2 Humedales*" aims to join efforts for the conservation and restoration of tropical forest ecosystems at the national level and of natural continental wetlands in the middle and lower Magdalena, as well as the formulation and implementation of actions for the mitigation of GHG emissions generated by avoiding the degradation of these ecosystems.

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1. Introduction

Continental natural wetlands are considered strategic ecosystems worldwide because of their importance in climate regulation. According to the Ramsar Convention, wetlands cover only 9% of the planet's land surface, but it is estimated that they store 35% of terrestrial carbon[1], thanks to the high productivity of plants and the low decomposition of organic matter that occurs in their flooded soils. In addition, wetlands are indispensable for the innumerable ecosystem services they provide to humanity, ranging from the provision of fresh water, food and building materials, and biodiversity, to flood control, groundwater recharge, and climate change mitigation[2].

However, the area and quality of wetlands have been decreasing in most regions of the world and are currently disappearing three times faster than forests consequently, among others, of the effects of climate change and variations in consumption patterns that drive changes in land use, resulting in accelerated land use change. Accordingly, the development and implementation of actions aimed at the conservation and restoration of natural Continental wetlands favors climate change mitigation and the permanence of the biodiversity associated with these ecosystems.

Consequently, within the framework of conservation and restoration measures for Continental natural wetlands, this methodology establishes guidelines for the development of activities related to the management of resources in these strategic ecosystems, to face the challenges of climate change and offer sustainable sources of income for the local communities.

This document provides GHG project holders with best practices related to procedures, models, parameters and data for quantifying GHG emission reductions and/or removals attributable to activities that avoid land use change and/or improve continental wetland ecosystem conditions. This document also provides guidelines for the identification of the baseline scenario, project boundaries and carbon stock variations.

2. Objectives

The objectives of this methodological document (hereinafter referred to as this Methodology) is set out:

1 https://www.ramsar.org/es

2 Ramsar, 2015. State of the World's Wetlands and their Services to People: A compilation of recent analyses. Available at: https://www.ramsar.org/sites/default/files/documents/library/strp19_4_bn7_e.pdf

(a) the methodological requirements necessary for the identification of the baseline for conservation and restoration projects in Continental natural wetlands;

(b) the requests for the quantification of GHG emission reductions resulting from conservation activities in Continental natural wetlands;

(c) the requirements for the quantification of GHG emission removals resulting from restoration activities in natural continental wetlands.

3. Version and validity

This document constitutes the document for public consultation. March 13, 2024.

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

4. Scope

This document provides a methodology for baseline establishment, quantification of GHG emission reductions and/or removals, monitoring and leakage management of Continental natural wetland conservation and restoration projects, contributing to climate change mitigation.

This methodology is applicable only for GHG mitigation projects that generate GHG emission reductions and/or removals through conservation and restoration activities in natural continental wetlands.

This methodology should be used by GHG project holders only for certification and registration under the BCR STANDARD.

5. Applicability conditions

This Methodology is applicable under the following conditions:

(a) The areas within the geographical limits of the project correspond to the category of Continental wetlands that are not located in the Orinoquia region[3];

(b) Project activities include actions to avoid the transformation of natural continental wetlands with natural vegetation cover;

3 The term Orinoquia refers to the entire Orinoquia region (present in Colombia and Venezuela). Projects located in the Orinoquia should use the BCR004 methodology.

(c) Project activities may include assisted natural restoration actions in areas that have been transformed;
(d) Project activities cannot generate a change in the type of ecosystem and its natural cover (e.g., transform areas that are naturally dominated by herbaceous species into forest cover).
(e) Project activities do not lead the alteration of the water regime of the project area or hydrologically connected areas due to anthropogenic interventions (e.g. irrigation and/or drainage systems);
(f) Soil disturbance attributable to project activities does not cover more than 10% of the surface area within the project boundaries;
(g) This methodology is not applicable to coastal-marine and high mountain wetlands, nor to artificialized territories.

6. Normative References

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

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

(b) IPCC 2003, 2006, 2013, and 2019 Guidelines for National Greenhouse Gas Inventories. Volume 4. Agriculture, forestry and other land uses, or those that modify or update them;

(c) National legislation in force, related to GHG projects, or those regulations that modify or update them, as applicable;

(d) The guidelines, other orientations and/or guides defined by BIOCARBON, in the scope of the projects in the AFOLU sector.

Likewise, it is essential to comply with the following ISO Standards:

a) ISO 14064-2:2019(es). Greenhouse gases - Specification with guidance, at the project level, for the quantification, monitoring and reporting of emission reductions or enhancement of greenhouse gas removals, or that which updates it;

b) ISO 14064-3:2019(es). Greenhouse gases - Part 3: Specification with guidance for validation and verification of greenhouse gas declarations, or that which updates it.

7. Terms and definitions

Activity Data

Data on the magnitude of human activities that result in emissions or removals occurring during a given time period.

Additionality

Is the effect of the GHG Project activity to reduce anthropogenic GHG emissions below the level that would have occurred in the absence of the GHG Project activity.

In the AFOLU sector, other than REDD+ projects, additionality is the effect of the project activity to increase actual net GHG removals by sinks above the sum of the changes in carbon stocks in the carbon pools within the project boundary that would have occurred in the absence of project activity.

Source: Adapted from Glossary CDM terms. Version 10.0

Agriculture, Forestry, and Other Land Use (AFOLU)

Sector comprising greenhouse gas emissions and/or removals attributable to project activities in the agriculture, forestry and other land use sector.

Baseline scenario

The scenario for the GHG project that reasonably represents the sum of carbon stock changes within the project boundary that would occur in the absence of the GHG project[4].

Carbon Fraction

Tons of carbon per ton of dry biomass. According to IPCC (2006) the carbon fraction is 0.47.

Conservation of wetland ecosystems

Activities that are developed with the purpose of preserving/conserving the carbon content available in natural wetland areas.

Deforestation drivers

Any natural or man-made action that generates changes in ecosystems[5]. They can be direct, when there is a strong influence on ecosystem functioning (climate variability, landscape

[4] Adapted of Glossary CDM terms. Version 10.0
5 Carpenter, S., Bennett, E., and Peterson, G. (2006). Scenarios for ecosystem services: An overview. Ecol. Soc. 11, art29. doi:10.5751/es-01610-110129

changes, nutrient injection into the soil for agricultural purposes, resource exploitation and use, and biological invasions) or indirect when their effect is not clearly visible (population growth, socio-political or economic trends, scientific advances to improve biomass production, and human behavior)[6].

Ecosystem

Dynamic complex of plant, animal and microorganism communities in their non-living environment that interact as a functional unit materialized in a territory, which is characterized by homogeneity in its biophysical and anthropic conditions[7].

GHG Emission Factor

Coefficient relating GHG activity data to GHG emission.

GHG Project (Greenhouse gases project)

Activity or activities that change the conditions of a GHG baseline and cause GHG emissions to be reduced or GHG removals to be increased[8].

Greenhouse gas reservoir (GHG reservoir)

A component, distinct from the atmosphere, that has the capacity to accumulate GHGs and to store and release them[18].

Note 1 to entry: The total mass of carbon contained in a GHG pool at a specific point in time can be referred to as the carbon pool of the pool.

Note 2 to entry: A GHG reservoir may transfer GHGs to another GHG reservoir.

Note 3 to entry: The collection of a GHG from a GHG source before it enters the atmosphere and the storage of the collected GHG in a GHG reservoir could be referred to as GHG capture and GHG storage.

Land use change

Changes in land use that constitute loss of natural cover. That is, changes generated by anthropic activities that result in the conversion of forests or natural vegetation cover to other

6 Nelson, G. C., Bennett, E., Berhe, A. A., Cassman, K., DeFries, R., Dietz, T. (2006). Anthropogenic drivers of ecosystem change: An overview. Ecol. Soc. 11 (2), 29. [online] URL: http://www.ecologyandsociety.org/vol11/iss2/ art29/.
7 In accordance with the definition contained in the Convention on Biological Diversity (1992). Available at: https://www.cbd.int/
8 ISO 14064-3:2019(es), 3.4.1.

land uses. When the land use change is from forest cover to another type of cover, it is called deforestation[9].

Leakages

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

Natural area

An area that is characterized by the conservation of its ecological functions and has not been transformed by man.

Natural continental wetland

Permanently or temporarily flooded ecosystems, typical of floodplains, subject to the hydro-climatic behavior of the basin, ranging from areas with saturated soils (to where the soils show evidence of oxidation-reduction processes): redoximorphic conditions) and hydrophytic vegetation (adapted to withstand periods of flooding), to areas with visible and deep water mirrors, where organisms (microbiota, fauna and flora) with particular adaptations to wet conditions are found and which offer ecosystem services and uses that benefit the local and regional community[10].

Natural forest

A minimum area of land between 0.05 and 1.0 hectares (ha) with a canopy cover (or equivalent stocking density) exceeding 30% and with trees that can reach a minimum height of 5 meters (m). A forest may consist of dense forest formations, where trees of various heights and undergrowth cover a considerable proportion of the ground, or of a clear stand. Natural forest stands and all young plantations that have not yet reached a crown density of 30% or a tree height of between 2 and 5 m, as well as areas that are normally part of the forest area but are temporarily devoid of forest population as a result of human intervention, e.g., harvesting, or natural causes, but which are expected to revert to forest, are also considered forests[11]

9 BCR0003 Quantification of GHG Emissions Reduction. Activities that prevent land use change and improve management practices for peatlands and other wetlands in high mountain ecosystems. Version 3.0.
10 Definido en: Protocolo para la estimación de contenidos de carbono en humedales del Magdalena medio y bajo. Versión 1. (Fundación Natura y Ecopetrol, 2023.). Disponible en: https://natura.org.co/wp-content/uploads/2024/02/V1_Documento-metodologico-Protocolo-Carbono-Humedales-08-02-24.pdf
11 Adapted of UNFCCC. Marrakesh Accords. Available at https://unfccc.int/resource/docs/cop7/13a01.pdf. The project holder shall use the definition applicable in his country.

Permanence

The condition resulting from project activities whereby the system established within the project boundaries is continuously extended, ensuring that the function of conserving carbon stocks is maintained over time.

Project start date

Date on which activities that will result in actual GHG emission reductions or removals begin. For GHG projects applying this methodology, the start date corresponds to the date on which the implementation of project activities begins. These may be, for example, the planting of native species in transformed areas and/or the initiation of management actions that reduce pressure from the transformation of wetland areas with natural vegetation cover within the project boundaries.

Restauration

Restoration comprises intentional activities that initiate or accelerate the recovery of ecological functionality or reestablishment of an ecosystem that has been degraded, damaged or destroyed. Restoration includes interventions such as: (a) ecological restoration, (b) ecological rehabilitation, and (c) ecological recovery.

Ecological restoration consists of restoring the degraded ecosystem to a condition similar to the pre-disturbance ecosystem with respect to its composition, structure and functioning. In addition, the resulting ecosystem shall be a self-sustaining system and shall ensure the conservation of species, the overall ecosystem, as well as 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 should be self-sustaining, preserve some species and provide some ecosystem services.

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

This methodology presents the guidelines for the quantification of emission removals from revegetation[12] of continental natural wetlands.

12 Reestablishment of vegetation cover in which diverse biotypes are used, from herbaceous and shrubs to climbers and trees. Taken from:

Soil

Soil is a natural body made up of solid (minerals and organic matter), liquid and gaseous materials inhabited by macro and microorganisms that carry out permanent biotic and abiotic processes; it fulfills vital ecosystemic functions and services for society and the planet[13].

Soils cover most of the earth's surface; they are indispensable and determinant for the structure and functioning of water, air and nutrient cycles; they are an essential part of biogeochemical cycles, in which there is distribution, transport, storage and transformation of materials and energy necessary for life on the planet, as well as for biodiversity. Their formation can take thousands of years as a result of physical, chemical and biological weathering and weathering associated with the interaction between climate, geomorphology, the geological material that originates them and the organisms that live in them. Soils are systems where different types of processes occur, such as gains, losses, movements and transformations that leave their mark in the form of horizons[14].

Transformed area

Area that has experienced changes in its physical and biotics conditions.

Wetland

According to the Ramsar Convention on the Protection of Wetlands (Article 1) "wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters" (Ramsar, 1971) [15].

8. Project boundaries

8.1. Spatial boundaries

The GHG project holder shall demonstrate that the areas within the geographic boundaries of the project are natural Continental wetlands. In the absence of an established and officially

https://bibliovirtual.minambiente.gov.co/documentos/tesauro/R/REVEGETALIZACI%D3N.htm

13 USDA. (2006). Claves para la Taxonomía de Suelos. 10a ed. Washington D.C.: Soil Survey Staff. Departamento de Agricultura de los Estados Unidos. Servicio de Conservación de Recursos Naturales.

14 IDEAM, U.D.C.A., 2015. Protocolo para la identificación y evaluación de la degradación de suelos por erosión. IDEAM - MADS -U.D.C.A Bogotá D.C., Colombia., 170 págs. Versión 2. Publicación aprobada por el IDEAM, diciembre de 2015, Bogotá D.C., Colombia

15 https://ramsar.org/documents?field_quick_search=2550

declared boundary, the project proponent may delimit the wetland area based on existing peer-reviewed guidelines[16].

8.1.1. Eligible area for the restauration activities implementation

The project holder shall define the eligible area for the implementation of restoration activities, according to the following guidelines:

(a) Demonstrate that the area corresponds to transformed covertures;
(b) Demonstrate that the areas within the geographic boundaries of the project do not correspond to the category of natural cover, neither at the beginning of the project activities, nor five years prior to the project start date;
(c) Demonstrate that soil preparation activities do not include the removal of natural cover areas.

The cartographic inputs for the identification of land cover/use and the methodological process for the generation of land-use change information should be based on reliable information[17], based on use categories defined, for example, by the IPCC for national GHG inventories. These, in turn, should be consistent with the land use categories applicable in the country where the proposed GHG project is implemented. For the identification of natural vegetation cover other than forest, the GHG project holder shall use the categories defined by the CORINE Land Cover methodology, or the one applicable in the country where the project is developed.

8.1.2. Spatial boundaries associated with the implementation of conservation activities

Eligible area

Corresponds to the areas of natural cover[18] within the geographical limits of the project. For its identification, the project holder shall:

(a) Perform a multi-temporal analysis between the project start date (t=0) and five years after the project start date.

[16] For the case of Colombia is sugested the use of "Protocolo para la estimación de contenidos de carbono en humedales del Magdalena medio y bajo". Disponible en https://natura.org.co/wp-content/uploads/2024/02/V1_Documento-metodologico-Protocolo-Carbono-Humedales-08-02-24.pdf
[17] The project shall have adequate geographic data and cartographic information to assess land cover and land use during the historical reference period. Geographic data should be handled following international standards promoted by organizations such as ISO, OGC or the American Society for Photogrammetry and Remote Sensing. The project holder shall have geographic data and information with a minimum scale of 1:25,000. The accuracy of the coverage layer should be equal to or greater than 80%. Field data or high-resolution images must be used in the accuracy assessment. In case of not being able to meet the minimum accuracy value of 80%, the project holder must provide a justification that will be evaluated by the Conformity Assessment Body (CAB) as a methodological deviation.
[18] The guidelines described in section 7.1.1 apply.

(b) Eligible areas are only those areas that are maintained with natural cover during the analysis period.

(c) Land covers should be identified according to the land use and/or land cover classifications given by the IPCC or those applicable for the country in which the project activities are proposed.

Leakages area

Area outside the control of the GHG project holder with natural cover to which activities that generate changes in land use because of project activities may be displaced. For its definition, the project holder shall perform an analysis of agent mobility and determinants of land use change[19].

Reference area

This is the spatial boundary at which land use changes and carbon stock changes are estimated in the absence of the project.

The project holder shall define the reference area considering the following guidelines:

- Demonstrate that the determinants of land use change (drivers of transformation) are like those presented in the project area;
- Demonstrate that the environmental conditions (ecosystem type, cover, altitude, precipitation, slope, soils) are like those found in the project area;
- Demonstrate that land tenure is the same as that presented in the project area. In the case of including areas with different tenure figures, the project holder shall demonstrate that historically the transformation of land cover has not been impacted by the type of tenure;
- Demonstrate that the cultural and socioeconomic conditions (applicable legislation, governance system, land use) are like those present in the project area.

8.2. Carbon reservoirs and GHG sources

8.2.1. Carbon reservoirs

The Intergovernmental Panel on Climate Change (IPCC) estimates carbon stock changes in the following reservoirs: aboveground biomass, belowground biomass, dead wood, litter and soil organic carbon.

[19] The mobility distance of the agents can be determined from secondary studies or from the collection of primary information (participatory rural appraisal). The methods and results of the mobility analysis should be documented.

GHG project holders may choose not to consider one or more optional carbon reservoirs, if they provide transparent and verifiable information and demonstrate that such a choice will not lead to an over- or underestimation of the GHG emission reductions quantified by the project.

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

Table 1. Description of carbon reservoirs

Carbon reservoir	**Description**
Aboveground biomass	All aboveground living biomass, including stems, stumps, branches, bark, seeds and foliage.
Aboveground aquatic biomass	Biomass present in the littoral zone of aquatic ecosystems from aquatic vegetation and differentiated according to their life form. It is recommended to consider the dominant morphospecies for the calculation of biomass.
Belowground biomass	All living root biomass. Fine roots less than 2 mm in diameter are excluded, because they are often not empirically distinguishable from soil organic matter.
Deadwood	Includes non-living aboveground wood, whether standing or fallen, including dead roots and stumps 10 cm or more in diameter.
Litter	It comprises all non-living aboveground biomass (leaves, branches and fruit shells) in various stages of decomposition. It includes the detrital, humic and humic layers. A minimum diameter can be established beforehand to differentiate from detritus (e.g., <10cm). Live fine roots (smaller than the suggested diameter limit for low soil biomass) are included in the mulch when they cannot be empirically distinguished from it.
Soil Organic Carbon	Includes organic carbon in mineral and organic soils at a specific depth selected by the project holder.

The selection of carbon reservoirs to quantify changes in carbon reduction and/or removal at the project boundaries is shown in Table 2.

Table 2. Carbon reservoirs selection

Carbon Reservoir	Required (Yes/No/Optional)	Explanation / justification
Aboveground Biomass	Yes	The change in carbon content in this reservoir is significant, according to the IPCC.
Aboveground aquatic biomass	Optional	The carbon stocks in this reservoir are expected to increase because of the project's restoration activities.
Belowground biomass	Yes	The change in carbon content in this reservoir is significant according to the IPCC.
Deadwood and litter	Optional	The amount of carbon stored in this reservoir may increase due to project activities.
Soil Organic Carbon	Yes	The change in carbon content in this reservoir is significant according to IPCC, 2006.

8.2.2. Fuentes de GEI

The emission sources and associated GHGs are presented in Table 3.

Table 3. Emission sources and GHGs in the baseline and project scenario selected for wetlands.

Anthropic activities				
Fuente	GEI		Selection	Explanation/Justification
Woody biomass combustion	CO_2	Carbon Dioxide	No	CO2 emissions due to woody biomass combustion are not quantified as carbon stock changes according to the IPCC.
	CH_4	Methane	Yes	Should be included if the presence of fires/burns was identified during the monitoring period (e.g. woody biomass burning due to site preparation as part of land preparation).

Anthropic activities				
Fuente	GEI		Selection	Explanation/Justification
	N_2O	Nitrous oxide	Yes	Should be included if the presence of fires/burns was identified during the monitoring period (e.g. woody biomass burning due to site preparation as part of soil preparation).
Alteration of the water regime	CO_2	Carbon Dioxide	Yes	They should be included if land use changes are observed within the project boundaries.
	CH_4	Methane	Optional	Inclusion is suggested if it is identified that wetland transformation activities in the project scenario generate an increase in methane emissions.

8.3. Project temporal boundaries and analysis period

Project temporal boundaries correspond to the periods during which project activities are carried out and GHG emission reductions and removals are quantified.

The project temporal boundaries shall be defined considering the following:

(a) The start date of the project;

(b) The period of quantification of the reductions/removals; and (f) The period of quantification of the reductions/removals.; and,

(c) The monitoring periods.

Project emission reductions are accounted for during the project's quantification period. That is, the period during which the project holder quantifies GHG reductions/removals, measured against the baseline, for the purpose of request the issuance of Verified Carbon Credits (VCCs).

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

9. Baseline and additionality

To demonstrate that project activities generate Verified Carbon Credits (VCCs) that represent additional GHG emission reductions or removals, the Project Holder shall follow the guidance contained in the BCR Guidance "Baseline and additionality"[20]. The guidance contains provisions relating to additionality and baseline for projects under the BCR Standard[21].

On the other hand, GHG project holders shall demonstrate that emission reductions (or removals) do not correspond to emission reductions attributable to the implementation of legally required actions.

10. Drivers of transformation identification

To identify the drivers of transformation, a prospective analysis is proposed, which is a method that includes action, holder ship and anticipation as the basis for establishing future starting points[22]. It is based on hierarchies of influence and dependence "from" and "on" each of the variables, avoiding bias among the identified components[23].

The identification of the drivers of transformation is carried out in two steps:

1. Literature review of the project area;
2. Creation of concerted spaces with local stakeholders, including participants representing civil society, trade unions or productive sectors, local organizations and the public sector.

To define the influence and dependence of the transformation drivers in the project area, the use of the MICMAC[24] software is suggested. In MICMAC each of the identified drivers are added (including an acronym and its conceptual definition), for their subsequent qualification.

Table 4. Criteria for qualification of drivers of transformation based on the concept of the actors consulted and the available literature information.

Score	Influence
0	Null
1	Low
2	Moderate
3	High

[20] https://biocarbonstandard.com/tools/additionality.pdf
[21] The BCR Baseline and Additionality Guidance is a mandatory guidance covering the requirements established to ensure a realistic and conservative estimate of baseline emissions; it also provides requirements to ensure that activities are additional in all eligible sectors.
[22] Martín, J.A. (1995). Prospectiva tecnológica: Una introducción a su metodología y a su aplicación en distintos países. Madrid: Fundación Cotec para la Innovación Tecnológica. 55 p.
[23] Senhadji-Navarro, K., Ruiz-Ochoa, M. A., & Rodríguez Miranda, J. P. (2017). Estado ecológico de algunos humedales colombianos en los últimos 15 años: una evaluación prospectiva. Colombia forestal, 20(2), 191-200
[24] Freely available software. It is suggested to use the version 6.1.2 2003/2004.

Based on the criteria assessed and the scale described in Table 4, the values are placed within the Direct Influence Matrix (MID), considering the influence of motor A on the others (dependence), and the dependence of motor A exerted on the others (influence), described in Table 5.

Table 5. Direct Influence Matrix (MID) for capturing data for rating of the transformation engines.

		Over			
		Influence			
	Dependence	Driver	D1	D2	D3	D4
From		D1				
		D2				
		D3				
		D4				

The result of the analysis will be a graphical output in the form of a Cartesian plane where, based on the spatial location of the different engines, it will be possible to identify the categorization and, therefore, the prioritization criteria that may be used for future actions.

Those drivers with low influence and dependence will be considered autonomous, those with low influence and high dependence will be the result of some actions, the determining drivers will be those with high influence and low dependence, while the key drivers (those on which efforts can be concentrated) will have high influence and dependence, as shown in Figure 1.

	Influence	
Dependence	**Determinants**	**Keys**
	High influence	High influence
	Low dependence	High dependence
	Autonomous	**Results**
	Low influence	Low influence
	Low dependence	High dependence

Figure 1. Interpretation of the map of influence and indirect dependence of the prospective analysis within the MICMAC.

For the interpretation of the results, consider both the indirect influence map (for prioritization) and the indirect influence graph (for determining interactions), as these are the product of the direct analysis established through the qualification of the participating stakeholders. Use the results of these analyses as a tool to define project activities that can reduce the pressure of natural cover transformation.

11. Project activities

Conservation and restoration activities should be designed based on an assessment of environmental and social conditions in the project area. The design of each project activity should include, at a minimum, the following:

(a) Activity ID;

(b) Relationship of activity to GHG emissions reduction and/or removal;

(c) Consultation mechanism for the definition of project activities and participatory construction aspects (if applicable);

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

(e) Implementation schedule;

(f) Indicators to report the progress of the activity: name, type[25], goal[26], unit of measurement and person responsible for the measurement.

Project activities should be aimed at promoting connectivity and rehabilitation of aquatic and terrestrial ecosystems to contribute to the conservation of species and livelihoods of local communities. Listed below are some of the activities that can be implemented by the project holder in accordance with the GHG mitigation objective.

Activities for the reduction of emissions generated by avoiding the transformation of wetland areas with natural vegetation cover (conservation activities):

- Establishment of long-cycle or perennial fruit trees (e.g. mango, citrus, soursop, loquat, guava, tamarind);

[25] Output, product or impact
[26] Expected value and time for compliance

- Establish wood energy woodlots for the use of timber for posts, firewood or infrastructure to reduce pressures on native species;
- Establishment of mixed fodder banks to produce feed for the different livestock species on the farms, in order to reduce the expansion of the agricultural frontier;
- Use of alternative energies (wind, photovoltaic, biogas) to reduce pressures on tree cover;
- Use of livestock waste (feces, urine, feed scraps, animal bedding) for composting and use in soil improvement on the farm;
- Establishment of infrastructure for livestock and nutritional management in temporary confinement (semi-stabling management by hours/day) to reduce soil compaction in natural areas and pastures;
- Fish production in ponds;
- Agronomic and veterinary technical support.

Activities for the removal of emissions generated by revegetation actions in wetland areas that have been transformed (restoration activities):

Restoration of degraded areas with tree cover prioritizing native species;

- Establishment of live fences with tree species and/or isolated trees in paddocks, maintaining them permanently;
- Recover the water courses of the micro-watersheds and/or springs with vegetative cover (trees and/or grasses) to prevent soil erosion and sedimentation of water sources.

12. Quantification of GHG emissions reduction and/or removals

12.1. Estimation of carbon content in reservoirs

12.1.1. Stratification

Generally, in natural Continental wetlands, vegetation zonation is not homogeneous, but rather there is a transition from the water mirror to the flood plain zone (Figure 2). For this reason, it is necessary to carry out a stratification process to improve the accuracy of the biomass estimations in the project.

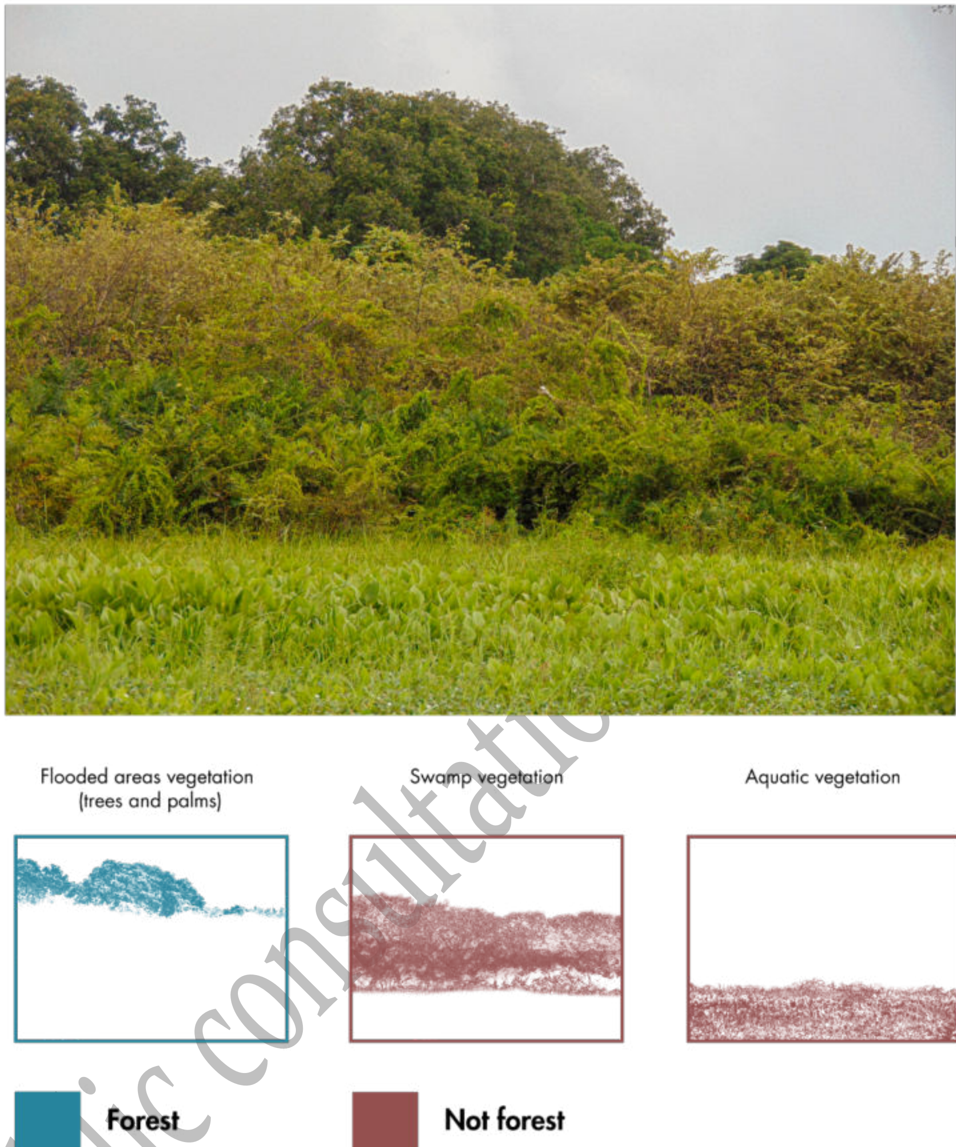

Figure 2. Vegetation zonation in natural Continental wetlands[27]

The project holder shall define different strata for the baseline scenario and for the calculation of mitigation results. This optimizes the accuracy in estimating GHG emission reductions or removals. In particular:

[27] Fundación Natura and Ecopetrol. 2023. Protocolo para la estimación de contenidos de carbono en humedales del Magdalena medio y bajo. Versión 1. Bogotá, Colombia. Available in: https://natura.org.co/wp-content/uploads/2024/02/V1_Documento-metodologico-Protocolo-Carbono-Humedales-08-02-24.pdf

(a) Para For the baseline scenario, it is usually sufficient to stratify the project area according to land use or land cover categories;

(b) For the project scenario, stratification can be based on the wetland conservation and restoration plans.

For project areas with natural cover, the following stratification is suggested:

Non-forest type cover: (Rial, 2003) floating and rooted emergent aquatic vegetation found over the water mirror and marsh vegetation that may include herbaceous and shrubby elements. Their characteristics are listed below:

- Aquatic vegetation (macrophytes associated with freshwater wetlands).
- Herbaceous vegetation (dominated by plants with heights between 0.3 and 1.5m) and ground level vegetation dominated by herbaceous plants with heights less than 30cm.
- Shrub type vegetation (plants between 1.5 and 5m high).

Forest type cover: woody vegetation defined by vegetation units dominated by plants with a height >5 m, characterized by having a stem or main axis, including elements such as trees and palms.

Figure 3 shows the vegetation components associated with each cover type.

Figure 3. Vegetation components in the strata for CO2 quantification in wetlands.

12.1.2. Type, size, number and design of sampling plots

Semi-permanent sampling plots are required, the number of which depends on the number of strata present in the project boundaries. These plots allow measuring and monitoring changes in biomass and shall be properly numbered, georeferenced and located within a map of areas established within the project boundaries.

Size of sampling plots or units

It is recommended to establish a plot size according to the vegetation cover conditions at the sites to be sampled.

Rectangular plots of 50 m x 10 m for a total area of 500 m^2, nested design. In the large plot the arboreal elements are monitored; inside this plot two 25 m^2 subplots are defined for the shrub elements, two 4 m^2 subplots for monitoring the herbaceous stratum, and finally two 1 m2 subplots for monitoring the aquatic vegetation found in the water mirror (Figure 4).

Note: in case no shrub elements are found in the monitoring area, it is recommended that information on this stratum be collected in the total area of the plot.

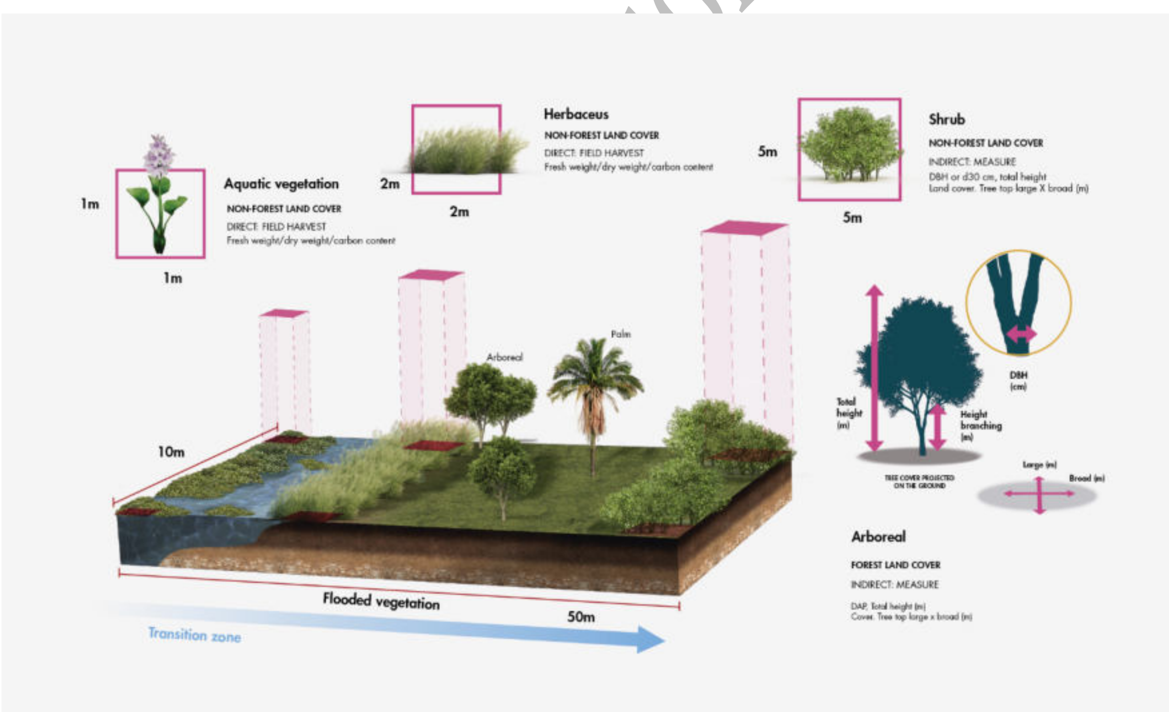

Figure 4. Plot design for the estimation of vegetation-associated carbon pools in wetlands of the middle and lower Magdalena[11]

Sample size

To calculate the number of plots (n) it is necessary to know the desired error in percentage (E), the number of total plots that could be established in the area of interest (N) (e.g., area of each stratum or project area), the variance (S^2) or the coefficient of variation in percentage (CV) associated with the variable of interest (in this case the biomass or carbon stored in the different pools) and the student's t-value for a given probability (α= 0.05). When different strata (H) are involved, the relative importance or proportion (Pj) occupied by each of them shall be considered for the calculation of the sample size.

The sampling precision is required to be within 10% of the true value of the mean, with a 95% confidence level. According to Kauffman et al., (2013)[28], the number of plots required can be calculated by the following formula:

$$n = \left(\frac{t * s}{\mathcal{E}}\right)^2 * \left(\sum_i W_i * S_i\right)^2 \qquad \text{Equation 1}$$

Where:

n	=	Number of sample plots required for carbon stock estimation within the project boundaries; no dimensions.
t	=	Bilateral Student's t-value at infinite degrees of freedom for the required confidence level; dimensionless.
$\mathcal{E}$	=	Acceptable margin of error in estimating carbon stocks within project boundaries; t d.m. (or t d.m. ha-1) units used for Si. Estimated using average wetland carbon stock data × 0.1 (10% desired precision).
W_i	=	Relative weight of the area of stratum i (i.e., the area of stratum i divided by the area of the project); dimensionless.
S_i		Estimated standard deviation of carbon stock in stratum i; t d.m. (or t d.m. ha-1).

[28] Kauffman, J., Donato, D., & Adame, M. (2013). Protocol for the measurement, monitoring and reporting of mangrove structure, biomass and carbon stocks. Working Document 117. Bogor Barat, Indonesia. Center for International Forestry Research.

i	1, 2, 3, … carbon stock estimation strata within the project boundaries.

Location of plots in the field

The establishment of the sampling units is done randomly or systematically. In the case of random sampling, with randomly selected points, subjective location of the plots (plot center, plot reference points or movement of the plot center to a more "convenient" position) should be avoided, following the principle of randomness[29].

Localization and georeferencing in the field with the use of GPS allows easy access and location. The sampling plots will be identified with alphanumeric code series and the information of their geographic position (GPS geographic coordinates), the location of the sampling unit and the strata will be recorded and archived.

12.1.3. Quantifying carbon content in aboveground biomass, belowground biomass, and litter reservoirs.

Table 6 and Table 7 present the recommended variables for the determination of biomass in forest and non-forest cover.

Table 6. Definition of variables for the determination of biomass in forest type cover.

Carbon reservoir	Method	Variable	Variable type
Aboveground tree biomass (ATB)	The indirect method, which consists of using allometric equations or expansion factors, is recommended.	Diameter at breast height (DBH)	Independent
		Height Wood density	Dependent
Belowground tree or root biomass (BTRB)	The indirect method, which consists of using allometric equations, is recommended.	Height DBH	Predictive variable
Litter	Fresh weight, Dry weight, C content (%)		

[29] In the case of stratified sampling, the centroid of the selected polygon is located, and this centroid is used to locate the plot. In the case of not being able to access the centroid, due to logistical issues, it is validated that it was within the defined stratum and the plot is randomly located.

Table 7. Definition of variables for the determination of biomass in non-forest type cover.

Carbon reservoir	Method	Variables – Direct method
Aboveground non-tree biomass (ANB)	For herbaceous and aquatic vegetation, the direct method is used, which consists of harvesting at ground level (or over the water mirror in the case of macrophytes) all the material found within the subplot or quadrant defined for this purpose. For shrub type vegetation, aerial biomass is determined indirectly using allometric equations.	Fresh weight, Dry weight, C content (%)
Belowground non-tree biomass (BNB)	For aquatic vegetation, the direct method is used, in which the root system of the macrophyte is separated separately from the sample harvested for the previous item. For shrub type vegetation, the determination of root biomass is done indirectly using allometric equations.	
Litter	Fresh weight, Dry weight, C content (%)	

Biomass estimation from indirect methods

Preferably use equations specific to the area (local and national level), if not possible you can use general equations used in other regions as long as the conditions where they were generated are like those of the project area[30].

Aboveground tree biomass (ATB)

The ATB, expressed in kilograms (kg), is calculated for the sampled tree individuals using the equation(s) that best fit the conditions of the project area. Some reference equations are referenced in Table 8.

[30] It is suggested to prioritize the use of allometric equations at the species, genus or family level.

Table 8. Allometric equations for the estimation of area biomass of trees and palms applicable to forest cover in Continental wetland areas.

Reference	Habit	Aboveground biomass equation	Provenance	Variables that consider
Chave *et al.* (2015)	**Tree**	$BA = 0.0673 \times ((\rho D2) \times H))^{0.976}$	Tropical	**DBH (D), wood density (ρ), total height (H)**
Álvarez *et al.* (2012)		$B = \exp(2.406 - 1.289 \times \ln(D) + 1.169 \times (\ln(D))^2 - 0.122(\ln(D))^3 + 0.445\ln(\rho))$	Tropical Humid Colombia	DBH (D), wood density (ρ)
Hughes *et al.* (1999)	Palm tree	$B = (\exp(3.627 + 0.5768\ln(H^*D^2))) \times 1.02/10^6$	Palms Mexico	DBH (D), total height (H)

Depending on the equation used, ATB is expressed as a function of normal diameter (D), specific wood density (ρ) and tree height (H). Once the ATB of each individual is calculated, the total ATB of each plot (ATB) is obtained by summing the ATB of all live trees registered. The ATB is then calculated in tons per hectare (t ha-1).

Belowground tree or root biomass (BARS)

BARS is estimated from ATB for each plot[31] (Equation 2).

$$BS = 0.489\ ATB^{0.890} \qquad \text{Equation 2}$$

Biomass estimation from direct methods

For the non-tree cover (herbaceous and aquatic), the direct method is used, which consists of harvesting the material in the subplots defined for this purpose, weighing it fresh; a sample of 300 grams is taken and then dried in an oven at 60°C for 24 to 72 hours until a constant weight is obtained.

Aerial non-tree biomass (ANB)

The value of ANB is estimated from Equation 3.

31 Using the equation suggested by Cairns et al. (1997): Cairns, Michael & Brown, Sandra & Helmer, E. & Baumgardner, Greg. (1997). Root biomass allocation in the world's upland forests. Ecologies. 111. 1-11. 10.1007/s004420050201

$$ANB = (DWm/WWm) \times WW \quad \text{Equation 3}$$

Where:

ANB	=	dry biomass of material harvested in the field (kg)
DWm	=	dry weight of the sample taken to the laboratory to determine the moisture content (kg).
WWm	=	wet weight of the sample taken to the laboratory to determine the moisture content (kg).
WW	=	wet weight of material harvested in the field.

Belowground non-tree biomass (BNAS)

The value of BNAS is estimated from Equation 4.

$$BNAS = (DWm/WWm) \times WW \quad \text{Equation 4}$$

Donde:

BNAS	=	dry biomass of material harvested in the field (kg).
DWm	=	dry weight of the sample taken to the laboratory to determine the moisture content (kg).
WWm	=	wet weight of the sample taken to the laboratory to determine the moisture content (kg).
WW	=	wet weight of material harvested in the field.

Biomass present in litter (BM - dead organic matter)

The value of BM is estimated from Equation 5

$$BM = (PSMOMm/PHMOMm) \times PHMOM \quad \text{Equation 5}$$

Where:

BM	=	biomass of the dead organic matter (litter) harvested in the field (kg)

DWMOMm	=	dry weight of the sample taken to the laboratory to determine the moisture content (kg) [32].
WWMOMm	=	wet weight of the sample taken to the laboratory to determine the moisture content (kg).

Total biomass (TB)

The TB per plot is calculated as follows:

$$TB = (ATB) + (BARS) + (ANB) + (\mathrm{BM}) \quad \text{Equation 6}$$

12.1.4. Quantification of carbon content in the soil organic carbon

To establish the carbon content in the soil, the methodology provided by the IPCC in its Guidelines for National Carbon and GHG Inventories that make up volume 4 ("Agriculture, Forestry and Other Land Use" - AFOLU) focused on wetland areas (organic soils, coastal soils and mineral soils of Continental wetlands) is used (IPCC, 2006). The proposed methodological process is presented below.

1. Preparation of basic information on the project area

Review of official information. For the case of Colombia, the soil studies published by IGAC (scale 1:100,000)[33] to identify the inventory of soils in the area with their respective classification according to the USDA system (official soil mapping).

The variables to be monitored to determine carbon and GHG dynamics in soils and sediments are bulk density, soil organic carbon (SOC), soil organic matter (SOM), texture (sand, silt and clay content).

2. USDA-IPCC soil homologation and integration with vegetation and land use.

With the basic information of the study area, the soil classification is homologated by integrating the USDA-IPCC soil homologation with the vegetation and land cover and land use units, according to Table 9 below.

32 Separate a sample (250-300gr) for subsequent laboratory determinations (dry weight).
33 INSTITUTO GEOGRÁFICO AGUSTÍN CODAZZI (IGAC). (2007). Manual de normas y especificaciones técnicas para los levantamientos edafológicos. Bogotá.

Table 9. Proposal for soil homologation

Soils order (USDA)	Abbreviation USDA	Determinant property	Type of soil (IPCC)	Abbreviation IPCC
Histosols	IST	Organic	Organic Soils	O
Andisols	AND	Volcanic	Volcanic Soils	VC
Entisols Inceptosols	ENT EPT	Coarse texture (>70% sand)	Sandy Soils	AR
		Fine, very fine or moderately fine texture (< 70% sand)	Other Mineral soils	OM
		Aqueous humidity regime	Wetland soils	H
Mollisols	OLL	High activity clays	High activity clays	HAC
Vertisols	ERT			
Alphisols	ALF			
Ardisols	ID			
Ultisols	ULT	Low activity clays	Low activity clays	LAC
Oxisols	OX			
Spodosols	OD	Low activity clays with spodic material	Spodic	OD
Gelisols	EL	Soils frozen to their maximum depth at some time of the year	Its formation is not possible under tropical conditions	

3. Selection of sampling points for on-site validation

Polygons to be monitored are identified and verified in the field to define the feasibility of sampling, possibility of access to the site in both high and low waters, validate land uses and establish some considerations to be considered at the time of sampling (organization of working groups for the sampling phase).

4. Soil and sediment sampling (field work)

Soil sampling is performed using the trunk system within the plots established for aerial biomass sampling (vegetation plot) with three replicates per plot. For sediments, aquatic bottom samples are taken at different depths; samples are also taken at the water's edge, associated with the sampling plots for aquatic vegetation; in any of the cases, at least three replicates shall be taken at each site. Soils and sediments will be differentiated by organic carbon content since only soils store organic carbon; the carbon content of sediments is associated with benthic organisms and biomass residues.

To determine bulk density, soil samples are taken using sampling cylinders of known volume, specific for this type of sampling. These samples shall be taken for each selected depth, deposited in an independent and labeled bag and included with the soil sample for SOC and texture. Once the samples have been taken, they shall be sent to the laboratory for their respective analysis.

Estimation of carbon content in soils

Soil carbon percentage (%)

Soil organic matter (SOM) content is determined by indirect methods associated with the conversion of soil organic carbon (SOC), since this element, being its main constituent, is the one determined in the laboratory. The SSL (1996) recommends using a correction factor equal to 1.724, if the organic matter has 58% organic carbon by means of the following equation:

$$\text{SOM}\ (\%) = \text{SOC}(\%)\ \text{x}\ 1.724 \qquad \text{Equation 7}$$

Where:

SOM (%)	=	Soil organic matter expressed in percent
SOC(%)	=	Soil organic carbon content expressed in percentage, determined by the Walkley Black method.

Bulk density

The bulk density is determined by applying Equation 8 and Equation 9 at a depth of 0-30 cm (0-30 cm)[34].

$$Density = \frac{Soil\ dry\ mass\ weight\ (g)}{Soil\ volume\ (cm^3)} \qquad \text{Equation 8}$$

$$Volume = \pi * r^2 * h \qquad \text{Equation 9}$$

[34] This depth is the minimum depth required to determine the carbon content in soils, according to IGAC and IPCC guidelines. For the carbon content estimation protocol, two depths are taken as reference, 0-25cm to identify the carbon content in full dynamics with the ecosystem (climate, sedimentation, etc.) and 25-50cm understood as the carbon content that is stored and that would only be emitted after an intense degradation process.

Where r is the radius of the cylinder and h is the height of the cylinder.

In case of soils with some limitation in depth that prevents sampling for the determination of bulk density, it is recommended to apply the model defined by IGAC-IvH (2018), where from the characterization of a total of 929 soil profiles, the correlation of the texture analyzed by the Bouyoucos method is performed and the following equation is established to obtain the bulk density of the soils:

$$Aparent\_Density = 1{,}331 + 0{,}0001A - 0{,}070SOC \qquad \text{Equation 10}$$

Donde:

Where:

Aparent_Desinty	=	apparent density of soil in g/cm^3
A	=	sand content in the soil in percentage (%)
SOC	=	oil Organic Carbon Content in percentage (%)

Soil carbon content

From the bulk density data and taking the sampled depth as a reference, the organic carbon content of the soil is determined from the following equation:

$$\text{SOC} = BD * A * D * SOC(\%)/100 \qquad \text{Equation 11}$$

Where:

SOC	=	Soil organic carbon stock (kg/m^2)
BD	=	Bulk density (kg/m^3)
A		Area of the UCS cartographic unit (m^2)
D	=	Sampling depth (m)
$SOC(\%)$	=	Soil organic carbon (%)

To determine the carbon content at different depths, the corresponding calculations are made and by means of the weighted average calculation, the carbon content in each layer is determined; to determine the content in the soil, the result obtained is added up to the maximum depth required[35].

12.1.5. Quantification of total carbon stocks in the reservoirs in year t

To convert the amount of carbon stored in the different reservoirs to the metric measure used to compare GHG emissions, i.e. CO2e, the amount of tons of carbon stored in the vegetation cover is multiplied by the constant (44/12) [36].

Total carbon in the reservoirs is estimated by stratum (Equation 12).

$$TC_{S,i} = (C_{BT} + C_{BM} + C_{SOC}) * \frac{44}{12} \quad \text{Equation 12}$$

Where:

CT_{Si}	=	Equivalent carbon content of the reservoirs of stratum i; tCO_{2e}
C_{BT}	=	Carbon content in biomass
C_{BM}	=	Carbon content in dead organic matter
C_{SOC}	=	Soil carbon content
$\frac{44}{12}$	=	Molecular ratio constant between carbon (C) and carbon dioxide (CO2).

To calculate the carbon stock in the defined strata, the total carbon of the stratum is multiplied by its corresponding area (ha):

35 Honorio, C., Baker, T. (2010). Manual para el monitoreo del ciclo del carbono en bosques amazónicos. Instituto de Investigaciones de la Amazonia Peruana / Universidad de Leeds. Lima, 54 p.
36 IPCC. (2006). Guidelines for National Greenhouse Gas Inventories, prepared by the National Grenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.

$$C_{Si}: \sum(CT_{Si} * A_{Ssi})$$ Equation 13

Where:

C_{Si}	=	Carbon content in stratum i; tCO_{2e}
CT_{Ss}	=	Corresponds to the sum of the carbon content of the reservoirs, of the stratum; $tCO_{2e}\ ha^{-1}$
A_{Ssi}	=	Area of stratum i; ha

12.2. Quantification of removals generated by the implementation of restoration activities

To estimate emission removals associated with restoration activities, the following steps are required:

1. Estimation of GHG removal in carbon reservoirs in the baseline scenario.
2. Quantification of the change in carbon reservoirs by as a result of restoration activities.
3. Estimation of emissions that can be displaced as a result of the implementation of mitigation actions.
4. Quantification of net removals.

12.2.1. Emissions in the baseline scenario

Emissions in the baseline scenario are estimated using emissions from changes in wetland dynamics and changes in carbon pools in natural Continental wetlands that would occur in the absence of conservation and restoration activities.

Consequently, emissions in the baseline scenario are calculated according to Equation 14, below:

$$E_{BL} = \sum_{i=1}^{n} BT_{BL,i,t} + E_{BL,fire,t} + E_{BL,ch,t}$$ Equation 14

Where:

E_{BL}	=	Emissions in baseline scenario; tCO_{2e}
$BT_{BL,i,t}$	=	Changes in carbon stocks in total biomass in the baseline scenario, in stratum i, at time t; tCO_{2e}
$E_{BL,fire,t}$	=	Emissions from woody biomass combustion and soil carbon in the baseline scenario, time t; tCO_{2e}
$E_{BL,ch,t}$	=	Emissions from changes in wetland area, at time t; tCO_{2e}
i	=	1, 2 ,3 …n, stratum; no dimensions
t	=	1, 2, 3 … t, year

Changes in carbon stocks in reservoirs

The removals in the baseline scenario can be calculated as follows:

$$\Delta C_{BL,t} = \Delta C_{TB_{BL,t}} + \Delta C_{BM_{BL,t}} + \Delta C_{SOC_{LB,t}}$$ Equation 15

Where:

$\Delta C_{BL,t}$	=	GHG removals in the reservoirs, in the baseline scenario, in the quantification period; t CO2-e
$\Delta C_{TB_{BL,t}}$	=	Changes in biomass carbon stocks, in the baseline scenario, within the project boundary in the quantification period; t CO2-e
$\Delta C_{BM_{BL,t}}$	=	Changes in carbon stocks in dead organic matter, in the baseline scenario, within the project boundary, in the quantification period; t CO2-e
$\Delta C_{COS_{LB,t}}$	=	Changes in soil carbon stocks, in the baseline scenario, within the project boundary, in the quantification period; t CO2-e

The calculation of carbon stocks in the selected reservoirs in year t follows the process described in section 12.1.

Note: Carbon stocks in the baseline scenario can be counted as zero if the following conditions are met:

1. Naturas cover existing prior to the start of the project activity is not harvested or removed throughout the duration of the project;
2. Natural cover existing prior to the initiation of the project activity does not suffer mortality due to cover competition generated by the project, or damage due to the implementation of the project activity, at any time.

CO_2 and other GHG emissions from reservoir combustion ($E_{BL,fire}$)

If the project holder identifies the presence of fires affecting the project area during the monitoring period, the project holder shall quantify the CH_4 and N_2O emissions caused by the combustion of biomass and organic soils, taking into account the guidelines presented in the 2006 IPCC guidelines for national GHG inventories.

Biomass burning is the largest natural (or semi-natural) source of non-CO_2 gas production. The amount released can be estimated using emission factors based on the amount of carbon released[37].

CO_2 and other GHG emissions due to biomass loss

According to IPCC (2019), fire is treated as a disturbance that affects not only biomass (particularly aboveground), but also dead organic matter (litter and dead wood); likewise for organic soils that have been drained.

Following IPCC guidelines, the process for estimating CO_2 and other GHG emissions is described below.

$$E_{fire\ (BL,TB)} = A_{BL}\ x\ M_{TB}\ x\ C_{f(TB)}\ x\ G_{ef(TB)} x\ 10^{-3}$$ [38] Equation 16

Where:

$E_{fire(TB,BL)}$	=	Greenhouse gas emissions from total biomass fire, in the baseline scenario; tons of each GHG (CH_4, N_2O).
A_{BL}	=	Area burned in the baseline scenario; ha

37 Pearson, T., Walker, S. & Brown, S. (2005). Sourcebook for Land use, Land-use change and forestry projects. Winrock International. 11-33 pp.

[38] The value 10-3 converts L_{fire} to tons.

M_{TB} = Mass of fuel available for combustion; tons ha-1. This includes biomass, litter and dead wood.[39]

C_f = Combustion factor; dimensionless[40].

G_{ef} = Emission factor; g kg-1 of dry matter burned[41]

CO2 and other GHG emissions from fires in drained organic soils

Emissions of CO2 and other GHGs from burning drained organic soils can be measured directly or estimated using data on the area burned along with default values for the mass of fuel consumed and emission factors provided by the IPCC[42].

$$E_{fire(SOC,BL)} = A_{LB}\ x\ \dot{M}_{B(SOC)}\ x\ C_{f(SOC)}\ x\ G_{ef(SOC)} x\ 10^{-3}$$ [43] Equation 17

Where:

$E_{fire(SOC)}$ = Greenhouse gas emissions from organic soil fire, in the baseline scenario; tons of each GHG (CH4, N2O).

A_{BL} = Area burned in the baseline scenario; ha

$M_{B\ (SOC)}$ = Mass of fuel (organic soil) available for combustion, tons ha^{-1}.[44]

[39] In accordance with IPCC guidelines, litter and dead wood pools are assumed to be zero for this methodology, except where there is a change in land use or reliable and verifiable data are available for the site. For available fuel mass see Modules (Biomass and MOC). For combustion of non-woody biomass in grassland and cropland, CO2 emissions do not need to be estimated and reported, because it is assumed that annual CO2 removals (through growth) and emissions (either through decomposition or fire) by biomass are in equilibrium.
[40] Default values in Table 2.6; defined by the IPCC, 2019.
[41] Defaults in Table 2.5; defined by the IPCC, 2019.
[42] IPCC, 2013.
[43] The value 10-3 converts L_{fire} to tons.
[44] In accordance with IPCC guidelines, litter and dead wood pools are assumed to be zero for this methodology, except where there is a change in land use or reliable and verifiable data are available for the site. For available fuel mass see Modules (Biomass and MOC). For combustion of non-woody biomass in grassland and cropland, CO2 emissions do not need to be estimated and reported, because annual CO2 removals (through growth) and emissions (either through decomposition or fire) by biomass are assumed to be in equilibrium.

$C_{f(SOC)}$	organic soil combustion factor, dimensionless[45]
$G_{ef(SOC)}$	organic soil emission factor, g kg-1 of dry matter burned[46]

12.2.2. Quantification of the change in carbon stocks as a result of restoration activities

Emissions in the scenario with project

Emissions in the with-project scenario are estimated using emissions from changes in wetland area and emissions from woody biomass combustion.

Consequently, emissions in the with-project scenario are calculated according to Equation 18, below:

$$E_p = \sum_{i=1}^{n} TB_{P,i,t} + E_{P,fire,t} + E_{P,ch,t}$$

Equation 18

Where:

E_P	=	Emissions in baseline scenario; tCO_{2e}
$TB_{P,i,t}$	=	Changes in carbon stocks in total biomass in the scenario with project, in stratum i, at time t; tCO_{2e}
$E_{fire,P,t}$	=	Emissions from woody biomass combustion and soil carbon in the with-project scenario at time t; tCO_{2e}
$E_{P,mh,t}$	=	Emissions from changes in wetland area, at time t; tCO_{2e}
i	=	1, 2 ,3 ...n, stratum; dimensionless
t	=	1, 2, 3 ... t, year

[45] Default values in Table 2.6; defined by the IPCC, 2019.
[46] Defaults in Table 2.5; defined by the IPCC, 2019.

Changes in carbon stocks

Changes in carbon stocks in Continental natural wetlands correspond to changes in carbon stocks minus GHG emissions, as a result of project activities.

Carbon stock changes are determined by GHG removals by sinks and should be calculated as follows:

$$\Delta C_{ACTUAL,t} = \Delta C_t - GEI_{E,t} \qquad \text{Equation 19}$$

Where:

$\Delta C_{ACTUAL,t}$	=	Current net GHG removals by sinks, in the quantification period; tCO_2-e
ΔC_t	=	Changes in carbon stocks in the project, occurring in the selected reservoirs, in the quantification period; tCO_2-e
$GEI_{E,t}$	=	Increase in GHG emissions, other than CO2, within the project boundary, as a result of project activities, in the quantification period; tCO_2-e

The changes in carbon stocks that occurred in the selected carbon pools during the quantification period can be calculated as follows:

$$\Delta C_{P,t} = \Delta C_{TB_{P,t}} + \Delta C_{BM_{P,t}} + \Delta C_{SOC_{P,t}} \qquad \text{Equation 20}$$

Where:

$\Delta C_{P,t}$	=	Changes in carbon stocks occurring in the selected pools, in the with-project scenario, in the quantification period; tCO_2-e
$\Delta C_{BT_{LB,t}}$	=	Changes in biomass carbon stocks, in the with-project scenario, within the project boundary in the quantification period; t CO_2-e
$\Delta C_{BM_{LB,t}}$	=	Carbon stock changes in dead organic matter, in the with-project scenario, within the project boundaries, in the quantification period; t CO_2-e
$\Delta C_{COS_{LB,t}}$	=	Changes in soil carbon stocks, in the with-project scenario, within the project boundary, in the quantification period; t CO_2-e

t = 1, 2, 3 … t, year

CO_2 and other GHG emissions from combustion of reservoirs ($E_{P,fire}$)

CO_2 and other GHG emissions due to biomass loss

$$E_{fire\ (P,BT)} = A_P\ x\ \dot{M}_{BT}\ x\ C_{f(BT)}\ x\ G_{ef(BT)} x\ 10^{-3}$$ [47]

Equation 21

Where:

$E_{fire(BT,LB)}$ = Greenhouse gas emissions from total biomass fire, in the baseline scenario; tons of each GHG (CH_4, N_2O).

A_P = Area burned in the baseline scenario; ha

M_{TB} = Mass of fuel available for combustion; tons ha-1. This includes biomass, litter and dead wood[48]

.

C_f = Combustion factor; dimensionless[49]

G_{ef} = Emission factor; g kg^{-1} of dry matter burned. [50]

CO_2 and other GHG emissions from fires in drained organic soils

$$E_{fire(SOC,P)} = A_P\ x\ \dot{M}_{B(SOC)}\ x\ C_{f(SOC)}\ x\ G_{ef(SOC)} x\ 10^{-3}$$ [51]

Equation 22

[47] The value 10-3 converts L_{fire} to tons.
[48] In accordance with IPCC guidelines, litter and dead wood pools are assumed to be zero for this methodology, except where there is a change in land use or reliable and verifiable data are available for the site. For available fuel mass see Modules (Biomass and MOC). For combustion of non-woody biomass in grassland and cropland, CO_2 emissions do not need to be estimated and reported, because annual CO_2 removals (through growth) and emissions (either through decomposition or fire) by biomass are assumed to be in equilibrium.
[49] Default values in Table 2.6; defined by the IPCC, 2019.
[50] Default values in Table 2.5; defined by the IPCC, 2019.
[51] The value 10-3 converts L_{fire} to tons.

Where:

$E_{fire(SOC)}$	=	Greenhouse gas emissions from organic soil fire, in the baseline scenario; tons of each GHG (CH_4, N_2O).
A_P	=	Area burned in the baseline scenario; ha
$M_{B\ (SOC)}$	=	Mass of fuel (organic soil) available for combustion, tons ha^{-1}.[52]
$C_{f(SOC)}$		organic soil combustion factor, dimensionless[53].
$G_{ef(SOC)}$		organic soil emission factor, g kg^{-1} of dry matter burned[54].

12.2.3. Estimate of emissions that may be displaced as a result of the implementation of mitigation actions

In accordance with the AR-ACM0003 methodology, the AR-TOOL15, A/R Methodological Tool, Version 02.0 (Estimation of the increase in GHG emissions attributable to the displacement of pre-project agricultural activities) is applied for the leakage analysis.

The tool is not applicable if the displacement of agricultural activities is likely to cause, directly or indirectly, drainage over wetlands.

As described in the tool, displacement of agricultural activities, in and of itself, does not result in leakage. Leakage occurs when the displacement of agricultural activities generates an increase in GHG emissions because of project activities carried out within the project boundaries.

Leakage attributable to the displacement of agricultural activities is considered negligible and can be quantified as zero under the following conditions:

[52] In accordance with IPCC guidelines, litter and dead wood pools are assumed to be zero for this methodology, except where there is a change in land use or reliable and verifiable data are available for the site. For available fuel mass see Modules (Biomass and MOC). For combustion of non-woody biomass in grassland and cropland, CO_2 emissions do not need to be estimated and reported, because annual CO_2 removals (through growth) and emissions (either through decomposition or fire) by biomass are assumed to be in equilibrium.
[53] Default values in Table 2.6; defined by the IPCC, 2019.
[54] Default values in Table 2.5; defined by the IPCC, 2019.

(a) animals are moved to existing grazing land and the total number of animals on the grazing land to which they are moved does not exceed the carrying capacity of the grazing land;

(b) animals are moved to existing, ungrazed pastures, and the total number of animals moved does not exceed the carrying capacity of the grazing land to which they are moved;

(c) animals are displaced to farmland that has been abandoned in the last five years;

(d) animals are displaced to forested land, and no logging, or the decrease in forested areas, does not occur due to the displaced animals;

(e) animals are moved to a zero (or mechanical) grazing system.

Any other cases, the lands within the project boundaries, from which pre-project agricultural activities are to be moved outside the project boundaries, are delineated and the area shall be estimated.

Leakage resulting from the displacement of pre-project agricultural activities should be estimated as follows:

$$Leakage_t = \text{Leakage}_{AGRIC,t} \quad \text{Equation 23}$$

Where:

$Leakage_t$	=	GHG emissions due to leakage, in year t; t CO_2-e
$Leakage_{AGRIC,t}$	=	Leakage due to displacement of agricultural activities in year t, estimated with the tool "Estimation of the increase in GHG emissions attributable to displacement of pre-project agricultural activities"; t CO_2-e

12.2.4. Quantification of net removals

Project GHG removals by reservoirs should be calculated as follows:

$$\Delta C_{REM,t} = \Delta C_{R,LB,t} - \Delta C_{R,ACTUAL,t} - Fuga_{R,t} \quad \text{Equation 24}$$

Where:

$\Delta C_{REM,t}$ = Net GHG removals by reservoirs, year t; t CO_2-e

$\Delta C_{R,ACTUAL,t}$ = GHG removals by reservoirs, in year t; t CO_2-e

$\Delta C_{R,LB,t}$ = GHG removals at baseline, in year t; t CO_2-e

$Leakage_{R,t}$ = GHG emissions due to leakage from removal activities, in year t; t CO_2-e

12.3. Quantification of the emission reductions because the conservation activities

To estimate the emission reductions associated with the implementation of actions to reduce the conversion of natural wetlands to other land cover, the following steps are required:

1. Quantification of emissions in the baseline scenario.
2. Quantification of emissions in the scenario with project.
3. Quantification of emission reductions generated by the implementation of conservation activities.

12.3.1. Baseline emissions quantification

Emission reductions from avoided land use changes, in the scenario with project, are estimated according to the equation:

$$ER_P = (t_2 - t_1) * \left(E_{BL} - E_P - E_{Leakages}\right) \quad \text{Equation 25}$$

Where:

ER_P = Emission reductions from the project; tCO_2e

E_{BL} = Emission from land use changes in the baseline scenario; tCO2e year-1

E_P = Emission from land use changes in the project area; tCO2e year-1

E_{AF} = Emission from land use changes in the leakage area; tCO2e year-1

Project area

Emissions that would be generated in the without-project scenario due to the conversion of Continental natural wetland areas to other land uses. GHG emissions are estimated by considering the amount of area that would be converted in the without-project scenario and the carbon content that would be emitted to the atmosphere if these areas are converted (Equation 26).

$$E_{LB} = \sum_{i=1}^{n} CAC_{BL,i,t} \left(TB_{BL,i,t} + SOC_{BL,i,t} + BM_{BL.i,t}\right) + E_{fire\_LB.i,t} \quad \text{Equation 26}$$

Where:

E_{BL}	=	Project emissions in the baseline scenario; tCO2e
$CAC_{BL,i,t}$	=	Projected change in the area with natural vegetation cover in the baseline scenario of the project, in the reference region; ha yr-1
$TB_{BL,i,t}$	=	Carbon content in the total biomass in the baseline scenario, in stratum i; t CO2e ha-1
$COS_{BL,i,t}$	=	Soil carbon content in the baseline scenario, in stratum i; t CO2e ha-1
$BM_{BL.i,t}$	=	Carbon content in the dead organic matter in the baseline scenario, in stratum i; t CO2e ha-1
$E_{fire\_BL.i,t}$		GHG emissions from carbon combustion in the baseline scenario[55].
i	=	1, 2 ,3 …n, stratum; dimensionless
t	=	1, 2, 3 … t, year

Projected change in area with natural vegetation cover (CAC)

Correspond to changes in land use in wetland areas that change from natural vegetation cover to transformed cover in the reference period. Activity data are evaluated in the selected reference region.

To define the activity data, the project holder shall perform a land use change analysis considering the following guidelines:

[55] The estimation of emissions from woody biomass combustion and soil carbon are quantified following the guidelines in section 12.2.

Obtain geographic and cartographic information for land use change analysis[56]. Table 10 should be filled out with the list of information used.

Table 10. Inputs for land use change analysis

Input (Vector/remote sensors)	**Spatial resolution**	**Spectral resolution**	**Temporary resolution**	**Generation date**

- Stratify natural cover following the guidelines in section 12.1.1.
- Generate a change detection analysis or multitemporal analysis[57] between the period t=-5 and t=0, which allows identifying changes in land use that have occurred in the project area. The result of this is a change matrix (Table 11).

Table 11. Land use change matrix

Strata/Class		t2				Area (ha)
		$Class_1$	$Class_2$	$Class_3$	$Class_4$	
t1	$Class_1$					
	$Class_2$					
	$Class_3$					
	$Class_4$					

[56] See criteria in section 8.1.2.
[57] The methodology allows the use of nationally available layers that meet the spatial and temporal resolution requirements as input for the elaboration of the matrix. The project holder must perform an accuracy analysis of the data to demonstrate that it meets the requirements set out in section 8.

Projected change in the area with natural vegetation cover (NSC) in the baseline scenario in the project area.

The annual historical changes in the project area in the baseline scenario are determined using the following equation:

$$CAC_{LB} = \left(\frac{1}{t_2 - t_1} \ln \frac{A_2}{A_1}\right) * AP \quad \text{Equation 27}$$

Where:

CAC_{BL}	=	change in area with natural vegetation cover in the project baseline scenario, in the reference region (ha/year)
t_2	=	year end of the reporting period in which the changes are analyzed
t_1	=	year of the reference period in which the changes are analyzed.
A_2	=	area in natural vegetation cover in the reference region in t2 (ha)
A_1	=	area in natural vegetation cover in the reference region in t1 (ha)
PA	=	eligible project area (ha)

Carbon content in reservoirs[58]

The estimation of carbon content in the pools is described in section 12.1. In this case, year t corresponds to the year in which the sampling for the estimation of carbon in the natural canopies is carried out.

Leakage area

$$E_{AF\_p} = \sum_{i=1}^{n} CAC_{AF\_Pp} * (TB_{AF,i,t} + SOC_{AF,i,t} + MOC_{AF.i,t}) \quad \text{Equation 28}$$

[58] The same procedure is followed to estimate the carbon content in the leakage area.

Where:

E_{AF_p} = Projected emissions the leakage area in the scenario with project; tCO2e

CAC_{AF_P} = Projected changes in the area with natural vegetation cover in the leakage area, with project scenario, (ha/year)

$TB_{AF,i,t}$ = Changes in carbon stocks in total biomass in the project scenario, in stratum i, at time t; tCO2e

$SOC_{AF.i,t}$ = Emissions in soil carbon stocks in the baseline scenario, time t; t CO2e

$MOC_{AF.i,t}$ = Emissions in the dead organic matter stocks in the baseline scenario, at time t; t CO2e

i = 1, 2 ,3 …n, stratum; no dimensions

t = 1, 2, 3 … t, year

Projected changes in the area with natural vegetation cover (CAC) in the baseline scenario, in the leakage area.

The annual historical changes in leakage area in the baseline scenario are quantified using the following equation:

$$CAC_{AF\_BL} = \left(\frac{1}{t_2 - t_1}\ln\frac{AF_2}{AF_1}\right) * AF \qquad \text{Equation 29}$$

Where:

CAC_{AF_BL} = change in area with natural vegetation cover in the baseline scenario of the leakage area, in the reference region (ha/year)

t_2 = year end of the reporting period in which the changes are analyzed

t_1 = year of the reference period in which the changes are analyzed.

AF_2	=	area in natural vegetation cover in the reference region of the leakage area in t2 (ha)
AF_1	=	area in natural vegetation cover in the reference region of the leakage area in t1 (ha)
AF	=	Leakage area (ha)

12.3.2. Quantification of emissions in the project scenario

Project area

Emissions in the with-project scenario are calculated according to Equation 30, below:

$$E_P = \sum_{i=1}^{n} CAC_P(TB_{P,i,t} + SOC_{P,i,t} + MOC_{P.i,t}) + E_{fire\_P.i,t} \quad \text{Equation 30}$$

Where:

E_P	=	Emissions in the project scenario; tCO2e
CAC_P	=	change in the area with natural vegetation cover in the scenario with project, (ha/year)
$TB_{P,i,t}$	=	Changes in carbon stocks in total biomass in the project scenario, in stratum i, at time t; tCO2e
$SOC_{P.i,t}$	=	Emissions in soil carbon stocks in the baseline scenario, time t; t CO2e
$MOC_{P.i,t}$	=	Emissions in the dead organic matter stocks in the baseline scenario, at time t; t CO2e
$E_{fire\_P.i,t}$		Greenhouse gas emissions from fire, in scenario with project [59]
i	=	1, 2 ,3 ...n, stratum; dimensionless

[59] See section CO_2 emissions.

Projected changes in the area with natural vegetation cover (NSC) in the project scenario, in the project area.

GHG emissions in the project area in the with-project scenario are quantified using the following equation:

$$CAC_P = CAC_{LB} * (1 - \%DC_P) \qquad \text{Equation 31}$$

Where:

CAC_P	=	change in the area with natural vegetation cover in the scenario with project, (ha/year)
CAC_{BL}	=	change in area with natural vegetation cover in the baseline scenario (ha/year)
$\%DC_P$	=	percentage of projected decrease in coverage changes due to the implementation of project activities

Leakage area

$$E_{AF} = \sum_{i=1}^{n} CAC_{AF\_P} * (BT_{AF,i,t} + SOC_{AF,i,t} + MOC_{AF.i,t}) \qquad \text{Equation 32}$$

Where:

E_{AF}	=	Emissions in the leakage area in the scenario with project; tCO2e
CAC_{AF_P}	=	change in the area with natural vegetation cover in the leakage area, scenario with project, (ha/year)
$BT_{AF,i,t}$	=	Changes in carbon stocks in total biomass in the project scenario, in stratum i, at time t; tCO2e
$SOC_{AF.i,t}$	=	Emissions in soil carbon stocks in the baseline scenario, time t; t CO2e

$MOC_{AF.i,t}$	=	Emissions in the dead organic matter stocks in the baseline scenario, at time t; t CO2e
i	=	1, 2 ,3 …n, stratum; no dimensions
t	=	1, 2, 3 … t, year

Projected changes in the area with natural vegetation cover (CAC) in the scenario with project, in the leakage area.

GHG emissions in the leakage area in the project scenario are quantified using the following equation:

$$CAC_{AF-P} = CAC_{AF\_LB} * (1 + \%ICC_{AF}) \quad \text{Equation 33}$$

Where:

CAC_{AF-P}	=	change in the area with natural vegetation cover in the leakage area, scenario with project, (ha/year)
CAC_{AF_BL}	=	change in area with natural vegetation cover in the baseline scenario (ha/year)
$\%ICC_{AF}$	=	percentage increase in coverage changes due to the implementation of project activities.

12.3.3. Quantification of emission reductions generated by the implementation of conservation activities

Project GHG reductions should be calculated as follows:

$$\Delta C_{CON,t} = \Delta C_{CON,LB,t} - \Delta C_{CON,ACTUAL,t} - Fuga_{CON,t} \quad \text{Equation 34}$$

Where:

$\Delta C_{CON,t}$	=	Net GHG reductions from conservation activities, in year t; t CO2-e
$\Delta C_{ACTUAL,t}$	=	GHG reductions from conservation activities, in year t; t CO2-e

$\Delta C_{LB,t}$	=	GHG emissions at baseline, in year t; t CO_2-e
$Fuga_{CON,t}$	=	GHG emissions due to leakage from conservation activities, in year t; t CO_2-e

12.4. Estimation of the reduction and removals results of the project activities

GHG project results should be calculated as follows:

$$\Delta C_{PROYECTO,t} = \Delta C_{REM,t} + \Delta C_{CON,t} \quad \text{Equation 35}$$

Where:

$\Delta C_{PROYECTO,t}$	=	Net GHG reductions from conservation activities, in year t; t CO2-e
$\Delta C_{REM,t}$	=	Net GHG removals by reservoirs, year t; t CO_2-e
$\Delta C_{CON,t}$	=	Net GHG reductions from conservation activities, in year t; t CO_2-e
t	=	1, 2, 3 ... t, year

13. Monitoring plan

Project holders shall submit a monitoring plan in accordance with the standard and additionally describe the procedures for monitoring project activities and GHG emission reductions within the project boundary.

The GHG Project holder shall demonstrate that emission reductions or removals are quantified, monitored, reported and verified, through the application of the BCR Tool "Monitoring, reporting and verification (MRV)"[60].

[60] https://biocarbonstandard.com/wp-content/uploads/BCR_Monitoring-reporting-and-verification.pdf

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